

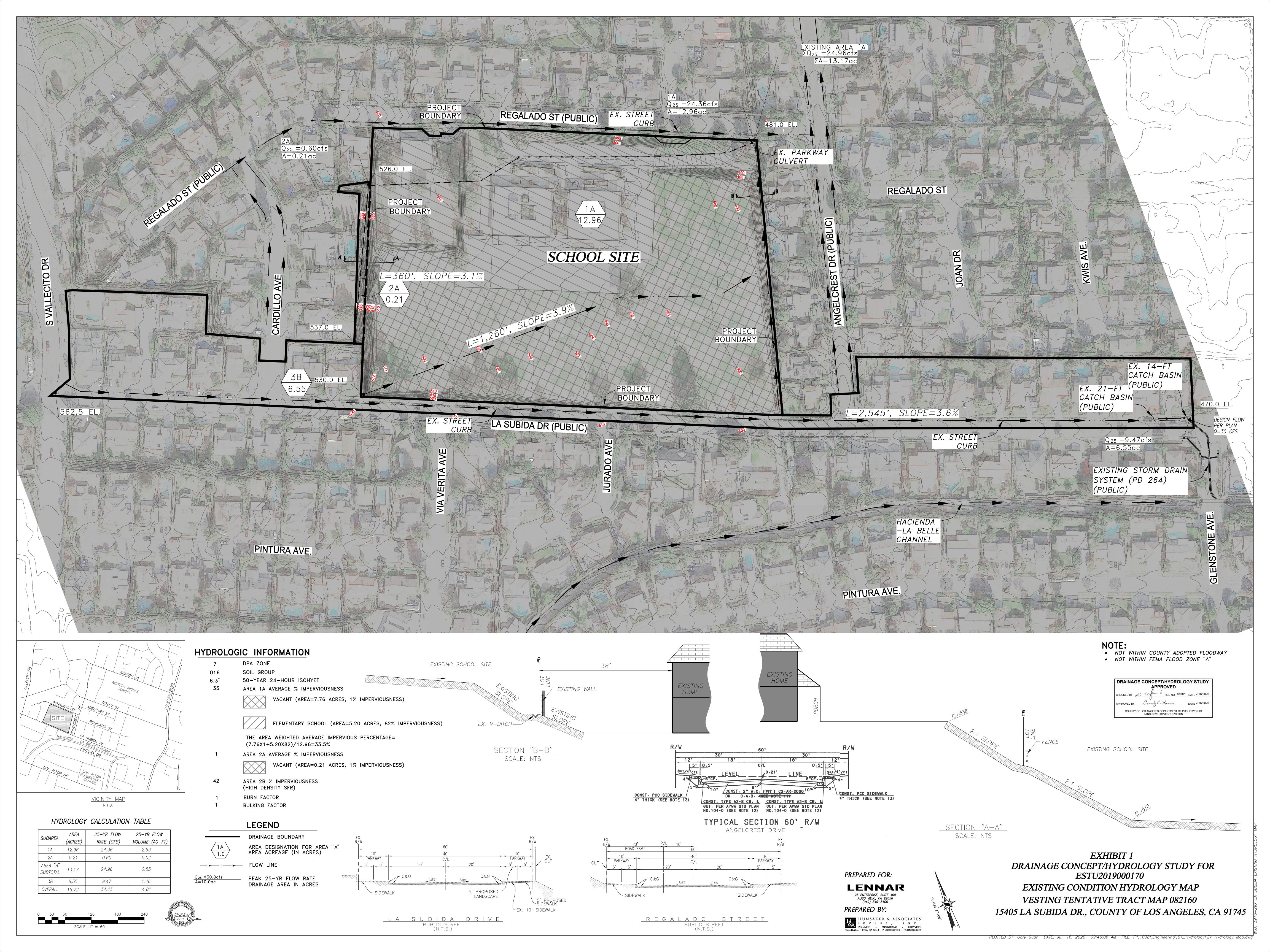
LAND DEVELOPMENT DIVISION HYDROLOGY UNIT

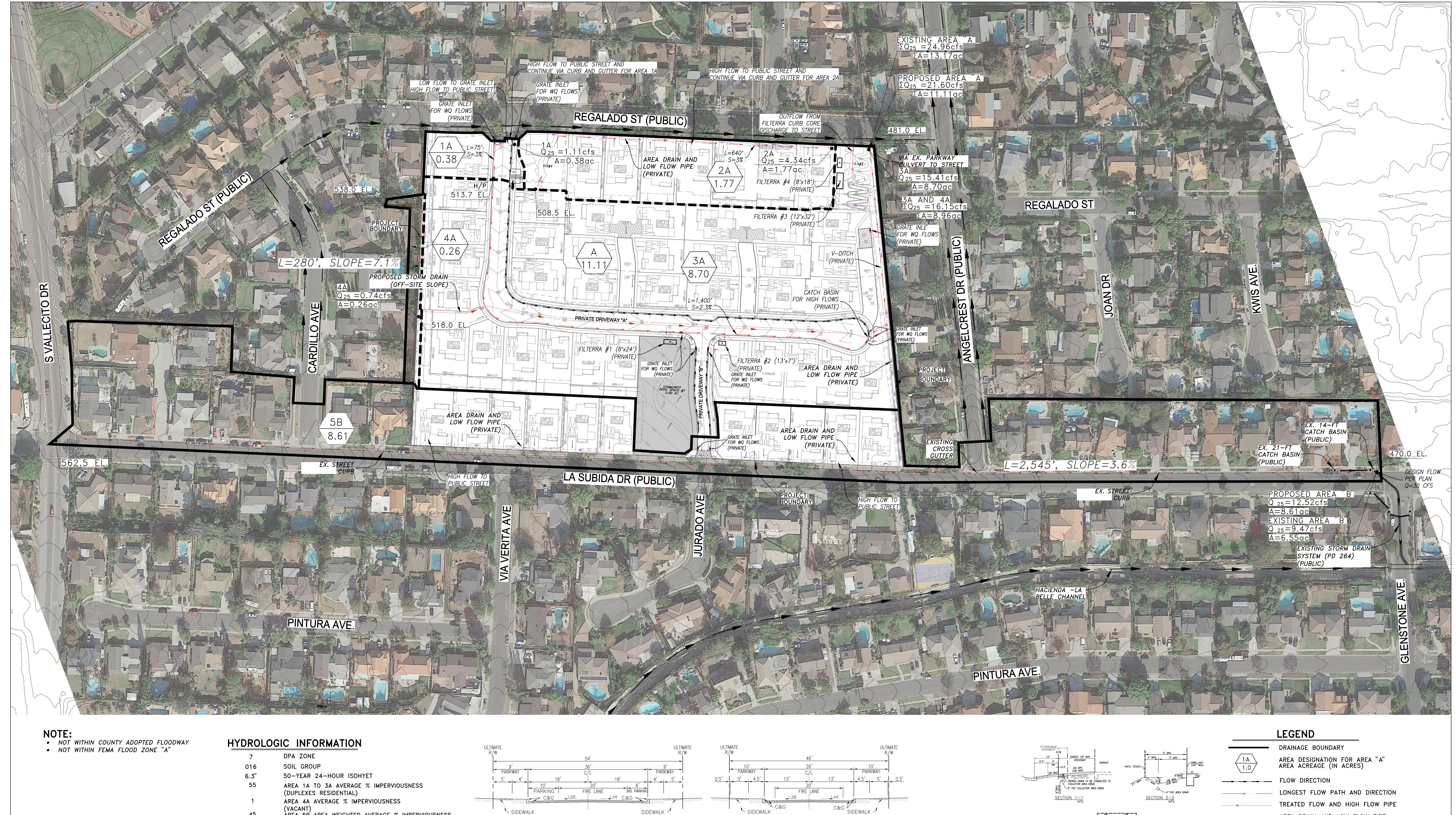
Hunsaker & Associates Irvine, Inc.

TO:

Date: 07/16/2020

	nes , CA 92618 rt Glessner		
REVIEW OF	HYDROLOGY STUDY		
TR NO.	82160	DATE OF REPORT PLAN CHECK NO. PLAN CASE NO.	07/16/2020 4 ESTU2019000170
We have revie	wed your Hydrology Study.		
[X] The Hy	drology Study has been approve	d.	
AYM			
REVIEWED B	Y M.O. ESFAND(6:	26) 458-4921	MANOUCHEHR DAVID ESFANDI No. C 0 43912 Exp. 6/30/21
APPROVED E	BY: Aracely C. Las	140	CIVIL OF CALLEDRAY





AREA 5B AREA WEIGHTED AVERAGE % IMPERVIOUSNESS THE PROJECT AREA (2.04 ACRES) HAS A 55% IMPERVIOUSNESS WITH DUPLEXES RESIDENTIAL LAND USE THE REST OFF—SITE AREAS WITHIN THE STUDIED BOUNDARY (SFR , AREA=6.57 ACRES, 42%

IMPERVIOUSNESS) THE AREA WEIGHTED AVERAGE IMPERVIOUS PERCENTAGE= (6.57X42+2.04X55)/8.61=45%

BURN FACTOR

BULKING FACTOR 85TH PERCENTILE RAINFALL DEPTH

RAINFALL DEPTH

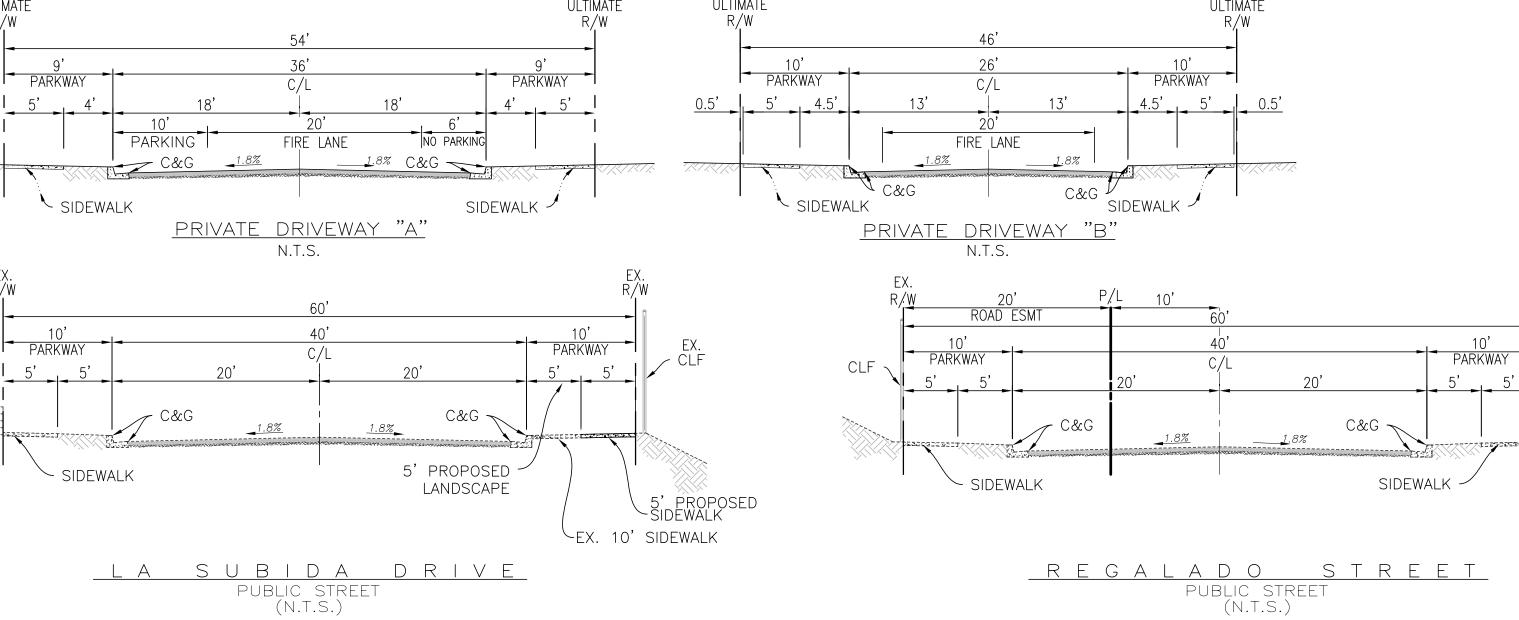
<u>VICINITY MAP</u>

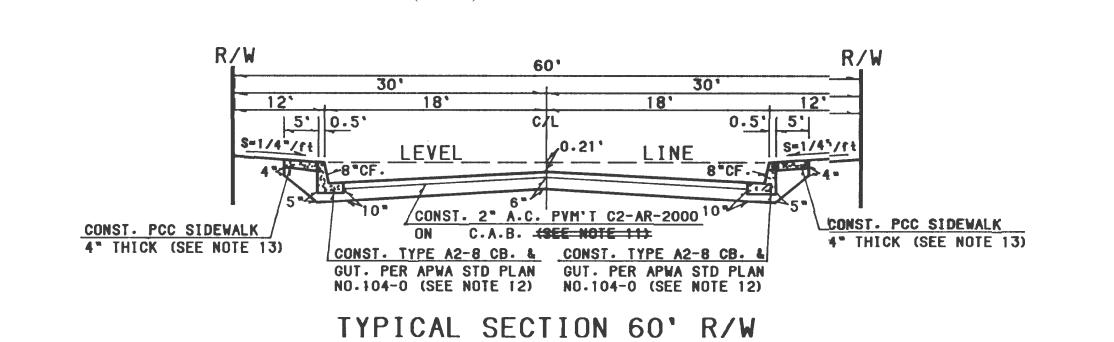
PROJECT DESIGN STORM (0.75 INCHES OR 85TH PERCENTILE)

PERCENT OF DESIGN STORM RETAINED ON-SITE PERCENT OF DESIGN STORM INFILTRATED OFF-SITE

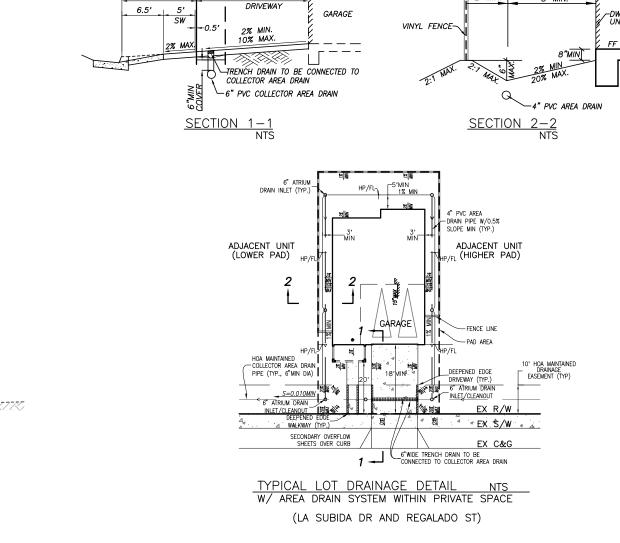
CUDADEA	AREA	25-YR FLOW	25-YR FLOW
SUBAREA	(ACRES)	RATE (CFS)	VOLUME (AC-FT)
1 <i>A</i>	0.38	1.11	0.10
2A	1.77	4.34	0.47
<i>3A</i>	8.70	15.41	2.31
4A	0.26	0.74	0.02
AREA "A" SUBTOTAL	11.11	21.60	2.90
4B	8.61	12.52	2.00
OVERALL	19.72	34.12	4.90

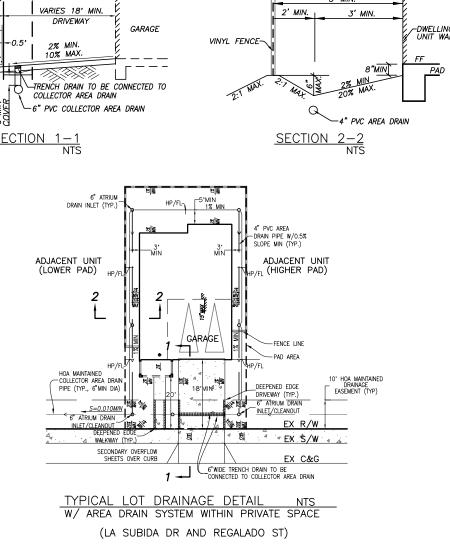
HYDROLOGY CALCULATION TABLE

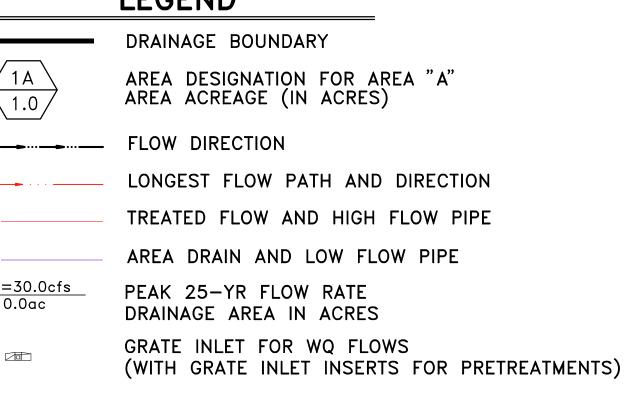




ANGELCREST DRIVE







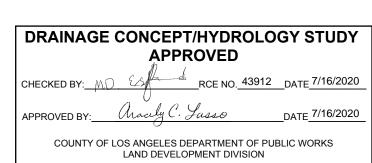
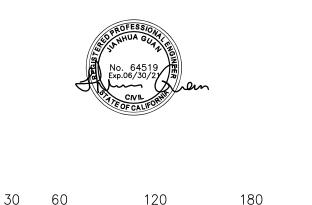


EXHIBIT 2 DRAINAGE CONCEPT/HYDROLOGY STUDY FOR ESTU2019000170 PROPOSED CONDITION HYDROLOGY MAP VESTING TENTATIVE TRACT MAP 082160 15405 LA SUBIDA DR., COUNTY OF LOS ANGELES, CA 91745

PLOTTED BY: Gary Guan DATE: Jul. 16, 2020 10:24:06 AM FILE: F:\1038\Engineering\SY_Hydrology\Proposed Hydrology Map.dwg



PUBLIC STREET (N.T.S.)

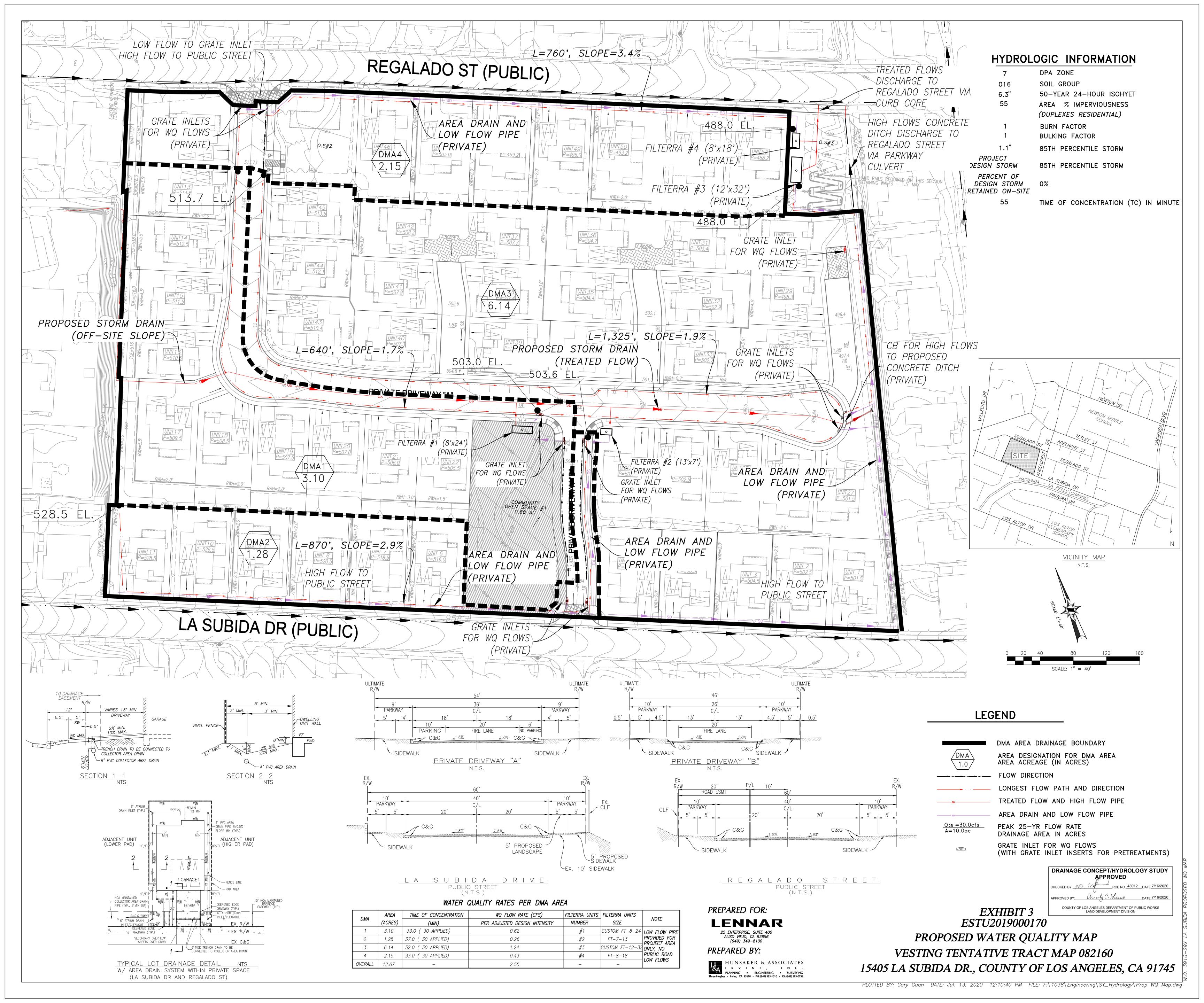
PREPARED FOR: LENNAR 25 ENTERPRISE, SUITE 400 ALISO VIEJO, CA 92656 (949) 349–8100 PREPARED BY: HUNSAKER & ASSOCIATES

I R V I N E , I N C .

PLANNING - ENGINEERING - SURVEYING

Three Hughes · Irvine, CA 92618 · PH: (949) 583-1010 · FX: (949) 583-0759







DRAINAGE CONCEPT/HYDROLOGY STUDY APPROVED

CHECKED BY: MD. ES

RCE NO. 43912 DATE 7/16/2020

APPROVED BY: Macely C. Jasso

_DATE_7/16/2020

COUNTY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS
I AND DEVELOPMENT DIVISION

DRAINAGE CONCEPT/ Hydrology Study

ESTU2019000170 "La Subida" Vesting Tentative Tract Map No. 82160 15405 La Subida Drive

County of Los Angeles

Prepared For:

LENNAR

15131 Alton Parkway, Suite 365 Irvine, CA 92618



Prepared By:



HUNSAKER & ASSOCIATES IRVINE, INC.

Three Hughes, Irvine, CA 92618 | 949.583.1010

DRAINAGE CONCEPT/HYDROLOGY REPORT

FOR

ESTU 2019000170

"LA SUBIDA" -

VTTM NO. 82160

15405 LA SUBIDA DRIVE

COUNTY OF LOS ANGELES

Prepared Date: 7/10/2020



PREPARED UNDER THE SUPERVISION OF:

7/10/2020

Jianhua "Gary" Guan, R.C.E. 64519, Exp. 06/30/21 Date:

TABLE OF CONTENTS

SECTION TITLE

- 1 INTRODUCTION & DISCUSSION
- 2 EXISTING CONDITION HYDROLOGY CALCULATIONS & MAP
- 3 PROPOSED CONDITION HYDROLOGY CALCULATIONS & MAP
- 4 LID AND FILTERRA UNIT SIZING CALCUALTIONS
- 5 PRELIMINARY HYDRAULIC UPDATES FOR PD 264, CATCH BASIN, STREET CAPACITY AND CROSS GUTTER CAPACITY CALC'S
- 6 REFERENCES
 - EXISTING STORM DRAIN PD264
 - RWQCB APPROVAL LETTER

SECTION 1 INTRODUCTION & DISCUSSION

A. INTRODUCTION

The proposed residential development for La Subida – Vesting Tentative Tract Map (VTTM) No. 82160 is located at 15405 La Subida Drive, in the Unincorporated County Area of Hacienda Heights, County of Los Angeles. The subject site is located on the north side of La Subida Drive, south of Regalado Street, east of existing residential lots located on Cardillo Avenue and west of existing residential lots located on Angelcrest Drive. The general location can be found from the vicinity map attached; Refer to Section 1, Page 5.

The site is presently a decommissioned elementary school that consists of classroom buildings, surface parking, playground and playfields. The overall property is approximately +/-13.17 gross acres and is generally a Trapezoid-shaped parcel. The school site is vacated and not in use. The proposed project would demolish all asphalt and paved areas, 3 existing buildings and school related structures, and landscaping.

Surrounding land uses include primarily residential land uses on all sides, including Regalado Street to the north, La Subida Drive to the south, easterly and westerly property boundaries.

The project site in located within Flood Zone "X" per FIRM Map 06037C1851F dated September 26, 2008.

LENNAR proposes Vesting Tentative Tract Map No. 82160 for the development of 52 single-family detached residential lots, parkways, on-street parking, private drives, curb, gutter, sidewalk and storm drain improvements, retaining walls, wet and dry utilities and related infrastructure improvements. There will be improvements to Regalado Street and La Subida Drive.

The subject property general plan land use designation is H5-Residential (0-5 du/ac).

B. DRAINAGE PATTERNS

The overall property is approximately +/-13.17 gross acres (12.99 net acres) in size and the site is currently an Elementary School owned and maintained by the Hacienda La Puente Unified School District (HLPUSD) that consists of classroom buildings, surface parking, playground and open spaces areas.

Stormwater and surface water onsite generally flow from south/southwest to north/northeast direction. The onsite storm runoffs discharge into Regalado Street and continue easterly along Regalado Street via street gutters allowing street flows. There are no existing storm drain systems in the immediate vicinities of the project site. Storm drain catch basins are located downstream on Jurado Avenue and Angelcrest Drive.

During the proposed condition, the majority of the project site will be proposed to follow the existing condition drainage pattern – discharging onto Regalado Street. The southern portion of the project will be proposed to discharge on La

Subida Drive where a single row of proposed residential lots front. The proposed low flow area drains and Filterra Offline Treatment Systems (FT-P) are proposed for intercept and treatment of the water quality flows. The storm drain catch basins (one 21-ft curb opening and one 14-ft curb opening) are located along La Subida Drive at the intersection with Glenstone Avenue. The existing storm drain (PD 264) is discharging into Hacienda – La Belle Channel. The existing storm drain plans for PD 264 can be found in Reference Section 6.

C. STUDY PURPOSE

The purpose of this study is to analyze pre-project and post-project hydrology of the project site to determine the peak flow rates of storm runoff and to compare with the allowable flows as well as to analyze the negative impacts, if any, due to the project developments.

D. HYDROLOGIC INFORMATION

A 25-year storm was analyzed for the project site. The project site encompasses the No.16 soil group. The 50-year 24-hour isohyet is approximately 6.3 inches. The project falls into DPA zone 7. The 85th Percentile, 24-hr Rainfall is approximately 1.1 inches. The reference Los Angeles County Hydrology Map GIS information can be found in Section I, Page 7.

The area weighted average of 33% of impervious percentage was applied for the existing condition Drainage Area A with 5.20 acres of school land use with 82% of imperviousness and 7.97 acres of vacant areas. A uniform 42% of impervious area (High Density Residential) was applied for existing condition Drainage Area B; refer to hydrology map for details.

The project area (Vacant and school in the existing condition) has a 55% of imperviousness with Duplexes, Triplexes, etc residential land use. The off-site areas remain the same with the same 42% of imperviousness for the <u>proposed condition</u> hydrology analysis.

E. METHODOLOGY

The methodology described in the Los Angeles County Department of Public Works (LACDPW) Hydrology Manual dated January 2006, was used to compute storm run-off from the project site. The LACDPW HydroCalc computer program was used to compute subarea time of concentration (TC), Peak Flow Rates and Runoff Volume. The hydrology calculations are included in Section 2 for existing (pre-project) and Section 3 proposed (post-project) conditions of this report.

F. HYDROLOGY CALCULATION RESULTS

The overall area studied (Drainage Areas A and B) including the off-site areas are approximately 19.72 acres in size. The runoffs from the area evaluated are conveyed via street flows and there are no existing storm drain systems in the immediate vicinity of the project site.

The summary of the hydrology study results and the comparisons between the existing and proposed conditions can be found in the following Hydrology Summary Table.

Hydrology Summary Table La Subida - VTTM 82160 County Of Los Angeles

Drainaga	Existing Condition (1)		Proposed Condition (2)		Differences (3)=(2)-(1)		
Drainage Area	Area	25-yr Storm	Drainage	Area	25-yr Storm	Area	25-yr Storm
	(acre)	(cfs)	Area	(acre)	(cfs)	(acre)	(cfs)
1A	12.96	24.36	1A	0.38	1.11	-	-
2A	0.21	0.60	2A	1.77	4.34	-	-
-	=	1	3A	8.7	15.41	-	-
-	-	-	4A	0.26	0.74		
Area "A" Subtotal	13.17	24.96	Area "A" Subtotal	11.11	21.60	-1.85	-2.76
В	6.55	9.47	В	8.61	12.52	2.06	3.05
Total	19.72	34.43	Total	19.72	34.12	0.00	-0.31

As indicated from the summary table, the overall peak flow rates slightly decrease due to the project development because of the storm runoff travel path changes and reduced flow path slope. The overall peak flow rate total decrease is 0.31 cfs for 25-year storm with 2.76 cfs decrease for Drainage Area "A" and 3.05 cfs increase for Drainage Area "B".

G. LID/WATER QUALITY

Due to existing soil conditions, percolation is constrained. This will require all filtration water quality devices to be sized per Adjusted Design Intensity to Provide Additional Capture In Lieu of Volume Reduction (see attached below).

The design storm is determined using the 0.75 inch storm or the 85th percentile storm, whichever is greater. The 85th Percentile, 24-hr Rainfall is approximately 1.1 inches per Los Angeles County Hydrology Map GIS information. The 85th percentile storm (1.1 inches) was selected as the project design storm. The Time of Concentration (TC) calculations from the 85th percentile storm can be found in Section 4 by applying the LACDPW HydroCalc computer program.

Table 6: Adjusted Design Intensity to Provide Additional Capture In Lieu of Volume Reduction (Option B)

5	100	action (Option)			
	Reliable Infiltration Rate at Site			F-	
Adjusted Time of Concentration (min)	0 in/hr (ET only) Capture Efficiency Target = 93.8%	0.01 in/hr Capture Efficiency Target = 94.1%	0.05 in/hr Capture Efficiency Target = 95.4%	0.15 in/hr Capture Efficiency Target = 98.1%	
20 20	Adjusted MWS Design Precipitation Intensities, in/hr				
5	0.55	0.57	0.66	N/A	
7.5	0.51	0.53	0.60	0.96	
10	0.48	0.49	0.57	0.90	
15	0.44	0.45	0.52	0.79	
20	0.41	0.42	0.48	0.74	
30	0.37	0.38	0.43	0.64	
60	0.31	0.31	0.35	0.50	

NA = additional capture is not a viable option to offset volume reduction in these cases.

There are 4 Filterra Offline Treatment Systems (FT-P) provided for the project. The water quality peak flow calculations can be found in Section 4. Along the public roadway frontier, the low flow lines are provided to collect the water quality flows from the project site and send to the proposed Filterra Units for treatments. The water quality flows from the public roadways and off-site areas are not treated by the proposed private Filterra Offline Treatment Systems (FT-P).

The detailed Low Impact Development (LID) can be found from the separate LID report and preliminary sizing for the Filterra systems can be found in Section 4.

F. PRELIMINARY HYDRAULIC UPDATES FOR PD 264, CATCH BASIN, STREET CAPACITY AND CROSS GUTTER CAPACITY CALC'S

Due to the project development and as shown from the hydrology summary table, the proposed condition flow rates along La Subida Drive (Drainage Area "B") are larger than the existing conditions

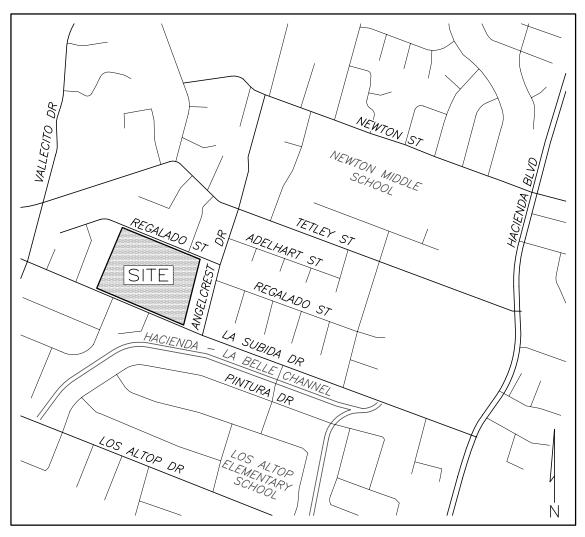
The street capacities along La Subida Drive were performed by applying the FlowMaster program. The catch basin sizing calculations were also performed for the existing catch basins (one 21-ft curb opening and one 14-ft curb opening) which are located along La Subida Drive at the intersection with Glenstone Avenue. The calculation results indicated that the street and catch basins have enough capacity to convey the proposed flows. As shown from the as-built plans

for PD 264, the design storm flow rate is about 30 cfs which is larger than the proposed 12.52 cfs.

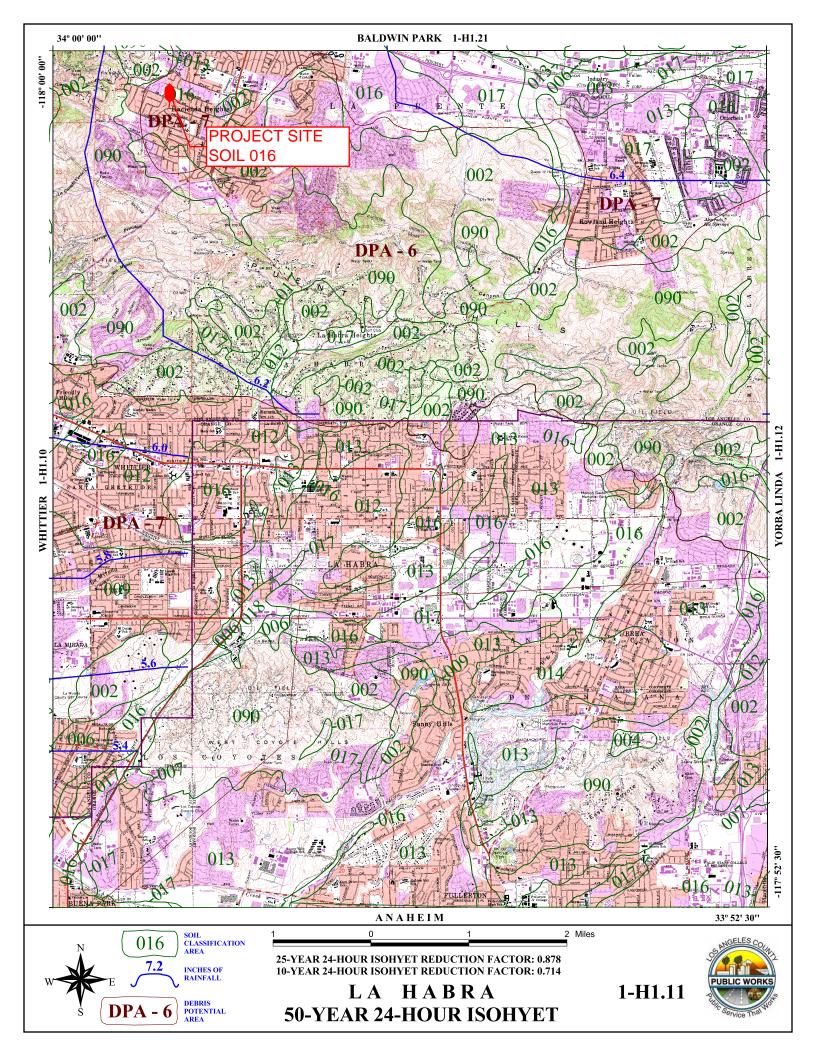
The preliminary hydraulic analysis were performed for PD 264 by applying the calculated flow rates for both the existing and proposed conditions. Detailed hydraulic calculations can be found in Section 5. The hydraulic calculation results indicated that the HGLs for both the existing condition and proposed condition are normalizing at downstream end of the existing 48" pipe where joins the culvert under Glenstone Avenue. The hydraulic calculation results also indicated that the proposed HGLs are well below the existing ground and meet the storm drain design requirements.

The cross gutter capacity analysis are also performed along La Subida Drive at the existing Anglecrest Drive intersection and the proposed Driveway "B" to ensure that the cross gutter has enough capacity to bypass the proposed flows. The hydraulic calculation results indicated that the cross gutter has enough capacity to convey the proposed flows without overtopping.

Overall, it is concluded that there will have no adverse impacts to the existing drainage systems due to the project developments.



VICINITY MAP N.T.S.



Hydrology Map A GIS viewer application to view the data for the hydrology manual. Wildwood High LAYERS Temple Ave Basemaps 50yr Two Tenths (Rainfall) DPA Zones La Puente High School Soils 2004 ✓ — Final 85th Percentile, 24-hr Rainfall Industry — Final 95th Percentile, 24-hr Rainfall □ 1-year, 1-hour Rainfall Intensity La Puente Main St SEARCH Enter Address, Cross Street, or Parcel No.: (ex: 900 S. Fremont Ave., Fremont@Valley, 5342005904) 15444 Regalado La Puente, CA 91745 Search Address Search Results: 15444 Regalado La Puente CA 91745 Hills unbull Canyon Rd Park Wilson (Glen A) High School Halliburton Rd Hacienda nan Hill Heights County of Los Angeles, Bureau of Lanc Q Map Tips

Hold SHIFT to drag a zoom location box. Hold SHIFT + CTRL to drag a zoom out location box.





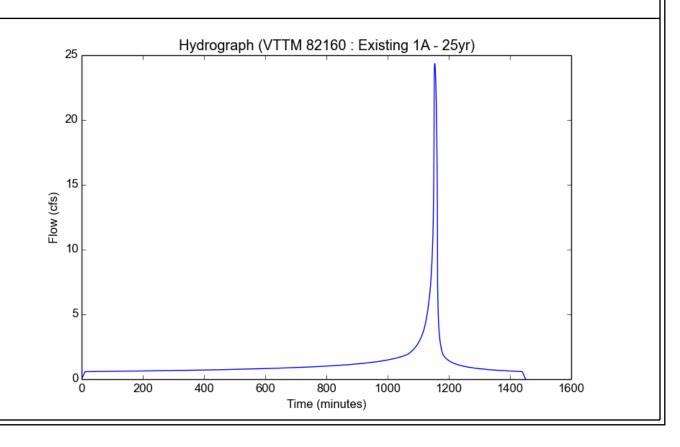


SECTION 2 EXISTING CONDITION HYDROLOGY CALCULATIONS AND MAP

 $\label{location:file_locatio$

Project Name	VTTM 82160
Subarea ID	Existing 1A - 25yr
Area (ac)	12.96
Flow Path Length (ft)	1260.0
Flow Path Slope (vft/hft)	0.039
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.335
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	2.2782
Undeveloped Runoff Coefficient (Cu)	0.7871
Developed Runoff Coefficient (Cd)	0.8249
Time of Concentration (min)	11.0
Clear Peak Flow Rate (cfs)	24.3558
Burned Peak Flow Rate (cfs)	24.3558
24-Hr Clear Runoff Volume (ac-ft)	2.5321
24-Hr Clear Runoff Volume (cu-ft)	110298.5842

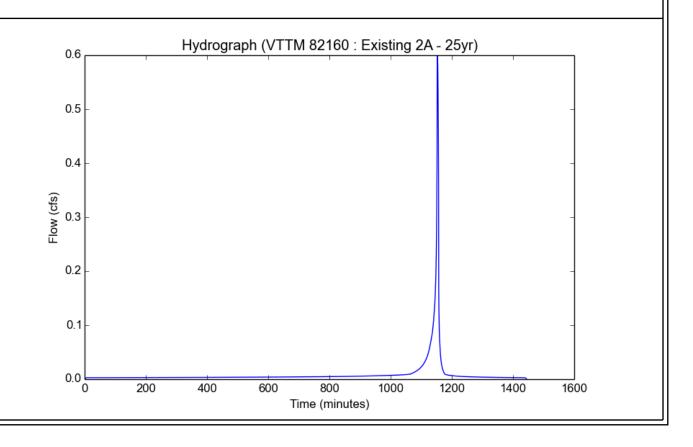


 $\label{location:file_locatio$

Input	Param	eters
-------	--------------	-------

Project Name	VTTM 82160
Subarea ID	Existing 2A - 25yr
Area (ac)	0.21
Flow Path Length (ft)	360.0
Flow Path Slope (vft/hft)	0.031
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.01
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	3.3002
Undeveloped Runoff Coefficient (Cu)	0.8648
Developed Runoff Coefficient (Cd)	0.8651
Time of Concentration (min)	5.0
Clear Peak Flow Rate (cfs)	0.5996
Burned Peak Flow Rate (cfs)	0.5996
24-Hr Clear Runoff Volume (ac-ft)	0.019
24-Hr Clear Runoff Volume (cu-ft)	825.5807

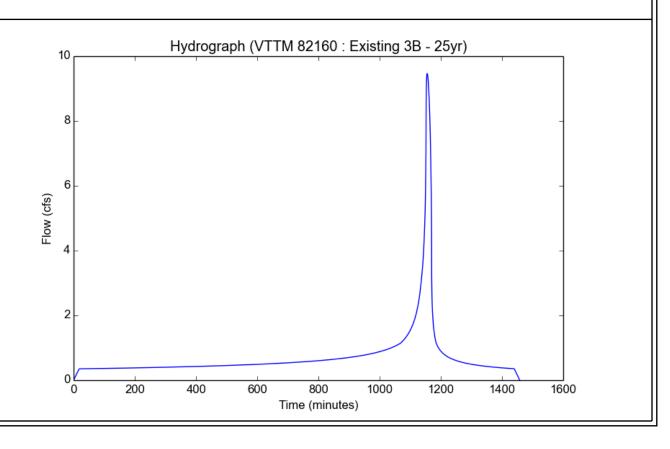


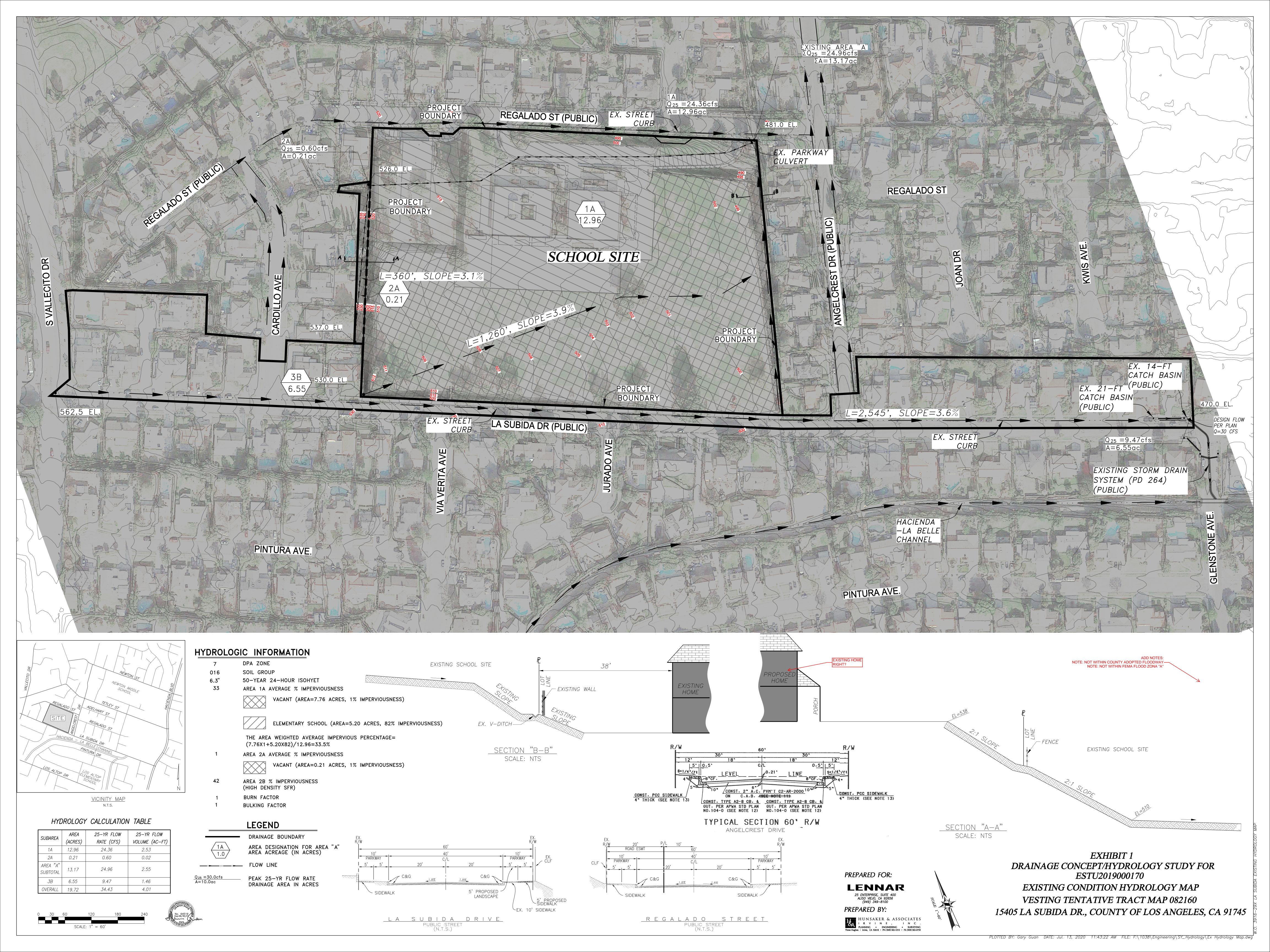
 $\label{location:file_locatio$

Input	Param	eters
-------	--------------	-------

Project Name	VTTM 82160
Subarea ID	Existing 3B - 25yr
Area (ac)	6.55
Flow Path Length (ft)	2545.0
Flow Path Slope (vft/hft)	0.036
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.42
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

o dispute 1 to o di to	
Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	1.8075
Undeveloped Runoff Coefficient (Cu)	0.7267
Developed Runoff Coefficient (Cd)	0.7995
Time of Concentration (min)	18.0
Clear Peak Flow Rate (cfs)	9.4652
Burned Peak Flow Rate (cfs)	9.4652
24-Hr Clear Runoff Volume (ac-ft)	1.4584
24-Hr Clear Runoff Volume (cu-ft)	63529.6815





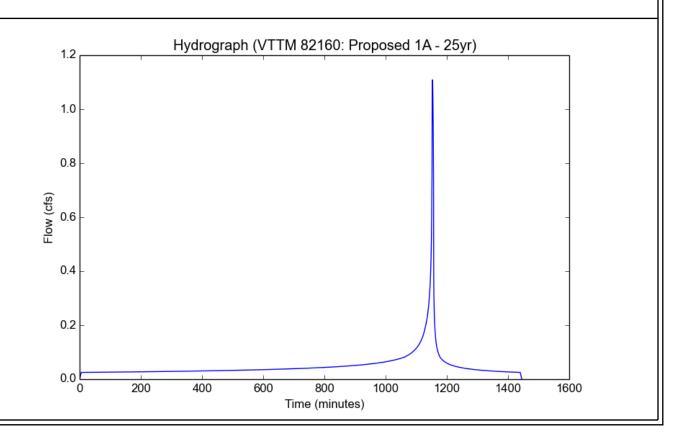
SECTION 3 PROPOSED CONDITION HYDROLOGY CALCULATIONS AND MAP

File location: F:/1038/Engineering/SY_Hydrology/Report/Updated/VTTM 82160 - Proposed 1A - 25yr.pdf Version: HydroCalc 1.0.3

Input	Param	eters
-------	--------------	-------

Project Name	VTTM 82160
Subarea ID	Proposed 1A - 25yr
Area (ac)	0.38
Flow Path Length (ft)	75.0
Flow Path Slope (vft/hft)	0.03
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

output Hoodilo	
Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	3.3002
Undeveloped Runoff Coefficient (Cu)	0.8648
Developed Runoff Coefficient (Cd)	0.8842
Time of Concentration (min)	5.0
Clear Peak Flow Rate (cfs)	1.1088
Burned Peak Flow Rate (cfs)	1.1088
24-Hr Clear Runoff Volume (ac-ft)	0.1009
24-Hr Clear Runoff Volume (cu-ft)	4393.7373

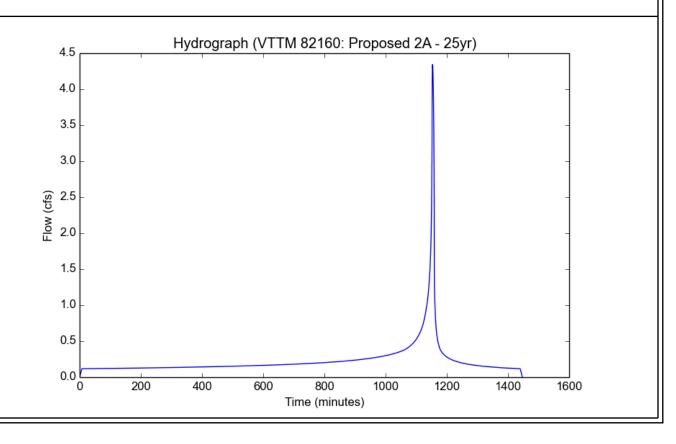


File location: F:/1038/Engineering/SY_Hydrology/Report/Updated/VTTM 82160 - Proposed 2A - 25yr.pdf Version: HydroCalc 1.0.3

Input	Parame	ters
-------	---------------	------

Project Name	VTTM 82160
Subarea ID	Proposed 2A - 25yr
Area (ac)	1.77
Flow Path Length (ft)	640.0
Flow Path Slope (vft/hft)	0.03
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	2.8175
Undeveloped Runoff Coefficient (Cu)	0.8353
Developed Runoff Coefficient (Cd)	0.8709
Time of Concentration (min)	7.0
Clear Peak Flow Rate (cfs)	4.343
Burned Peak Flow Rate (cfs)	4.343
24-Hr Clear Runoff Volume (ac-ft)	0.4697
24-Hr Clear Runoff Volume (cu-ft)	20460.6006

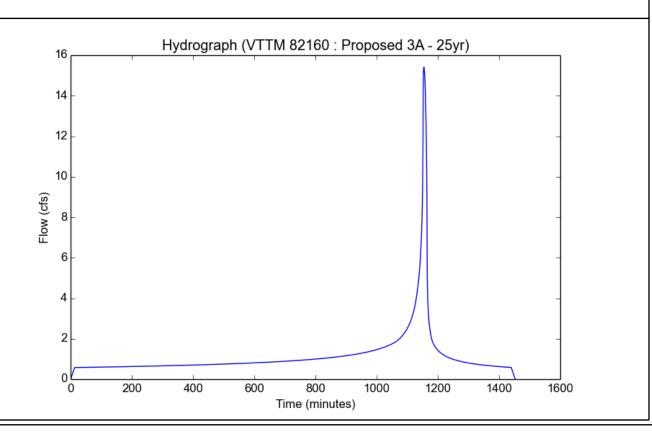


 $\label{location:File location:File locatio$

Input	Parame	eters
-------	---------------	-------

Project Name	VTTM 82160
Subarea ID	Proposed 3A - 25yr
Area (ac)	8.7
Flow Path Length (ft)	1400.0
Flow Path Slope (vft/hft)	0.023
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	2.1062
Undeveloped Runoff Coefficient (Cu)	0.7687
Developed Runoff Coefficient (Cd)	0.8409
Time of Concentration (min)	13.0
Clear Peak Flow Rate (cfs)	15.4088
Burned Peak Flow Rate (cfs)	15.4088
24-Hr Clear Runoff Volume (ac-ft)	2.307
24-Hr Clear Runoff Volume (cu-ft)	100491.2102

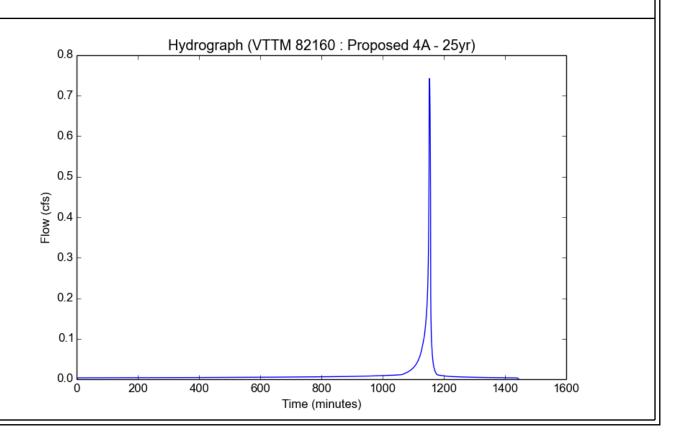


 $\label{location:FileIncation:$

Input I	Paramete	ers
---------	----------	-----

Project Name	VTTM 82160
Subarea ID	Proposed 4A - 25yr
Area (ac)	0.26
Flow Path Length (ft)	280.0
Flow Path Slope (vft/hft)	0.071
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.01
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

o a tpat i too a to	
Modeled (25-yr) Rainfall Depth (in)	5.5314
Peak Intensity (in/hr)	3.3002
Undeveloped Runoff Coefficient (Cu)	0.8648
Developed Runoff Coefficient (Cd)	0.8651
Time of Concentration (min)	5.0
Clear Peak Flow Rate (cfs)	0.7423
Burned Peak Flow Rate (cfs)	0.7423
24-Hr Clear Runoff Volume (ac-ft)	0.0235
24-Hr Clear Runoff Volume (cu-ft)	1022.1475

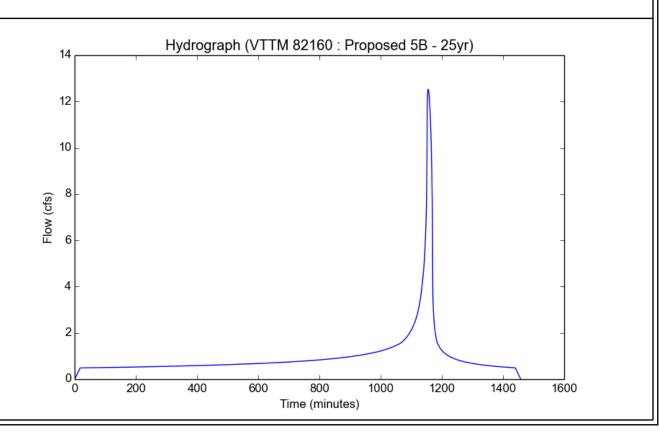


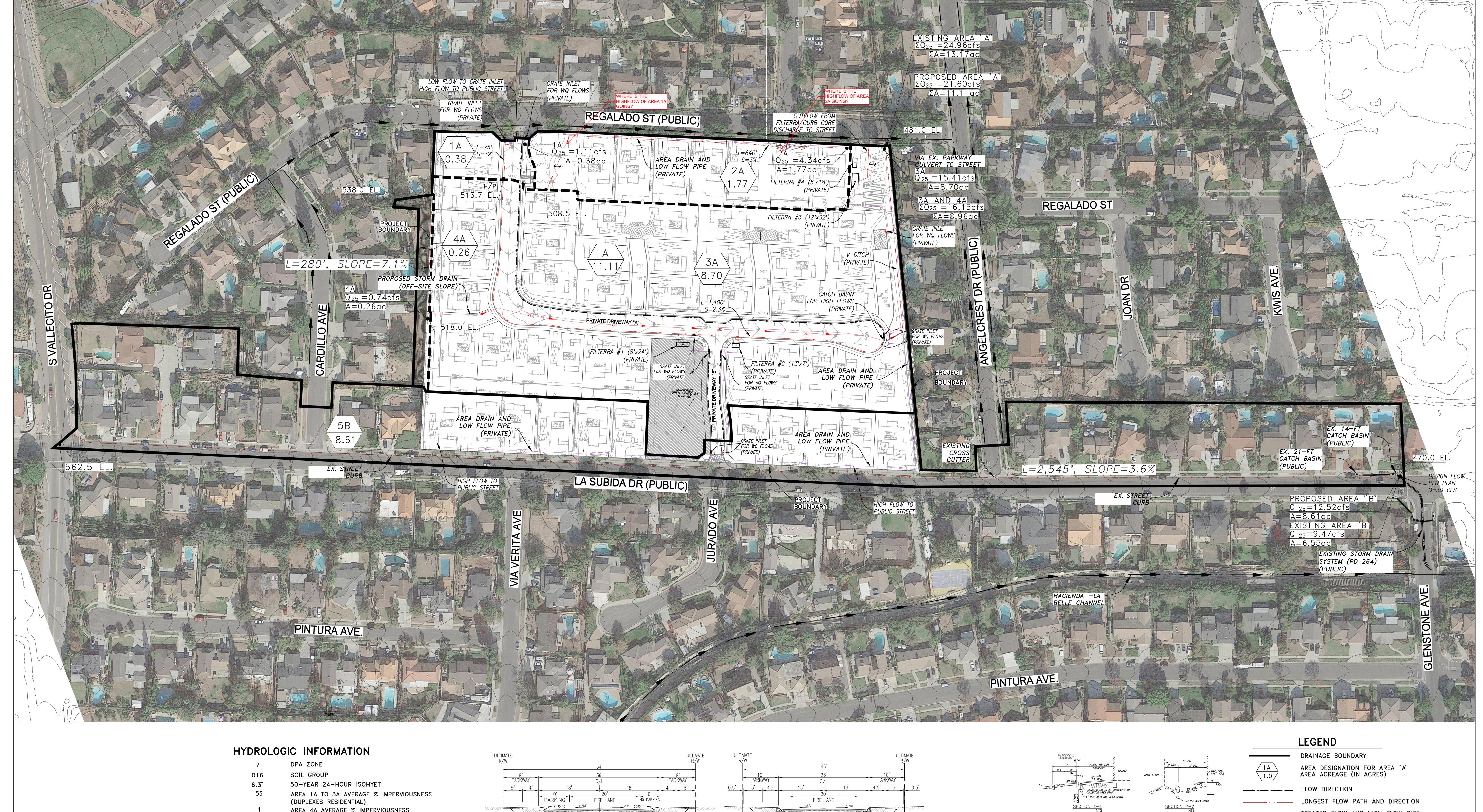
 $\label{location:FileIncation:$

Input	Param	eters
-------	-------	-------

Project Name	VTTM 82160
Subarea ID	Proposed 5B - 25yr
Area (ac)	8.61
Flow Path Length (ft)	2545.0
Flow Path Slope (vft/hft)	0.036
50-yr Rainfall Depth (in)	6.3
Percent Impervious	0.45
Soil Type	16
Design Storm Frequency	25-yr
Fire Factor	0
LID	False

o atpat recalls		
Modeled (25-yr) Rainfall Depth (in)	5.5314	
Peak Intensity (in/hr)	1.8075	
Undeveloped Runoff Coefficient (Cu)	0.7267	
Developed Runoff Coefficient (Cd)	0.8047	
Time of Concentration (min)	18.0	
Clear Peak Flow Rate (cfs)	12.523	
Burned Peak Flow Rate (cfs)	12.523	
24-Hr Clear Runoff Volume (ac-ft)	2.0012	
24-Hr Clear Runoff Volume (cu-ft)	87171.9107	





(DUPLEXES RESIDENTIAL) AREA 4A AVERAGE % IMPERVIOUSNESS

AREA 5B AREA WEIGHTED AVERAGE % IMPERVIOUSNESS THE PROJECT AREA (2.04 ACRES) HAS A 55% IMPERVIOUSNESS WITH DUPLEXES RESIDENTIAL LAND USE THE REST OFF—SITE AREAS WITHIN THE STUDIED BOUNDARY (SFR , AREA=6.57 ACRES, 42%

IMPERVIOUSNESS) THE AREA WEIGHTED AVERAGE

- IMPERVIOUS PERCENTAGE= (6.57X42+2.04X55)/8.61=45% BURN FACTOR
- **BULKING FACTOR** 85TH PERCENTILE RAINFALL DEPTH

RAINFALL DEPTH

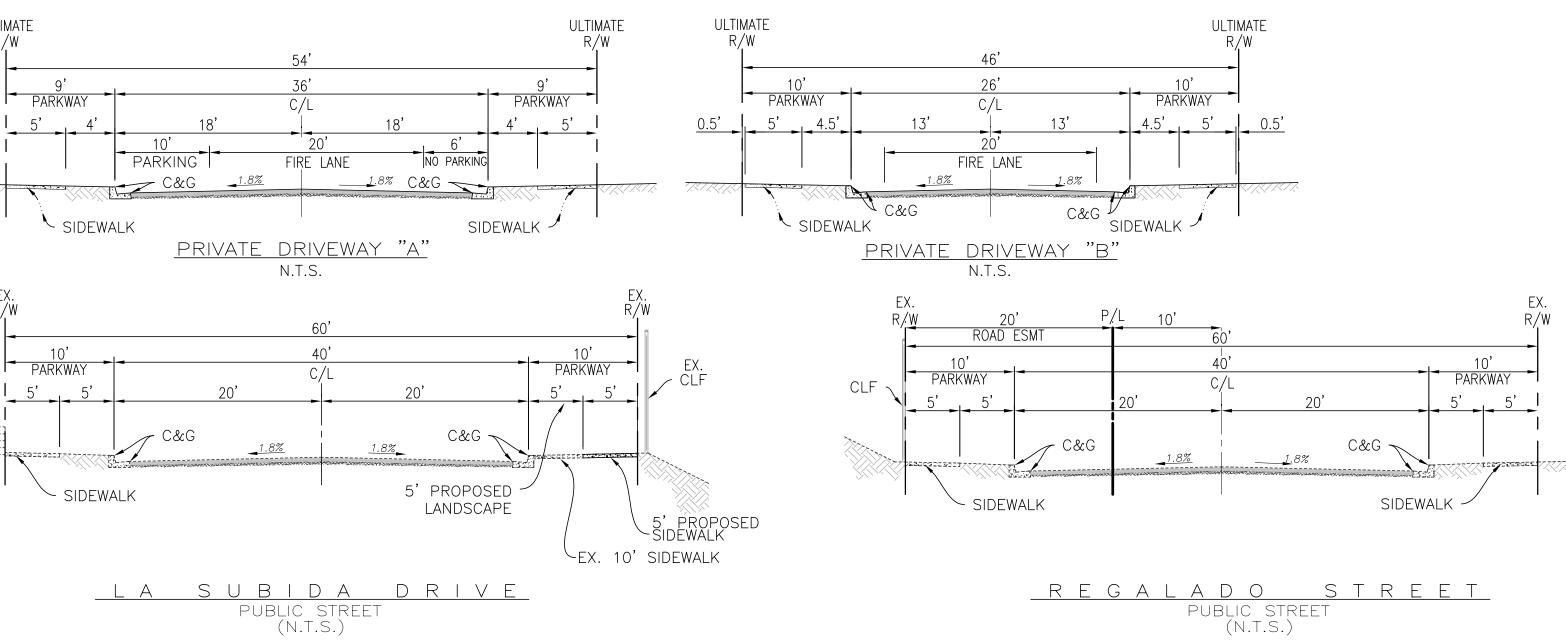
<u>VICINITY MAP</u>

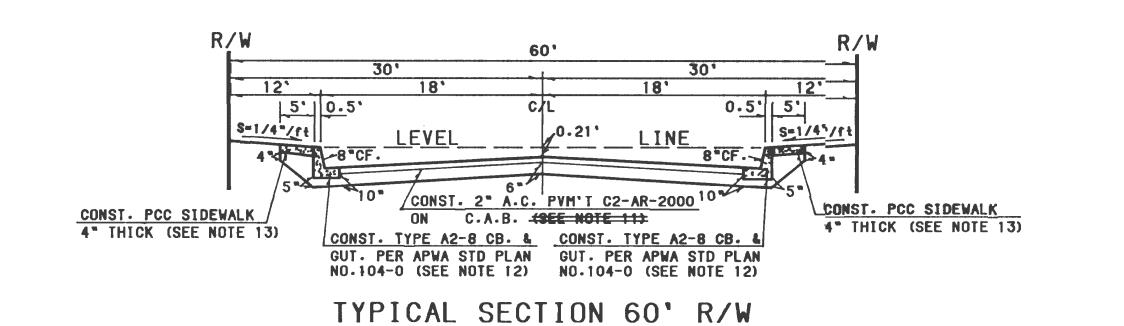
PROJECT DESIGN STORM (0.75 INCHES OR 85TH PERCENTILE)

PERCENT OF DESIGN STORM RETAINED ON-SITE

PERCENT OF DESIGN STORM INFILTRATED OFF-SITE HYDROLOGY CALCULATION TABLE

SUBAREA	AREA (ACRES)	25-YR FLOW RATE (CFS)	25-YR FLOW VOLUME (AC-FT)
1A	0.38	1.11	0.10
2A	1.77	4.34	0.47
<i>3A</i>	8.70	15.41	2.31
4A	0.26	0.74	0.02
AREA "A" SUBTOTAL	11.11	21.60	2.90
4B	8.61	12.52	2.00
OVERALL	19.72	34.12	4.90





ANGELCREST DRIVE



PREPARED FOR: LENNAR 25 ENTERPRISE, SUITE 400 ALISO VIEJO, CA 92656 (949) 349–8100 PREPARED BY: HUNSAKER & ASSOCIATES

I R V I N E , I N C .

PLANNING - ENGINEERING - SURVEYING

Three Hughes · Irvine, CA 92618 · PH: (949) 583-1010 · FX: (949) 583-0759

SECONDARY OVERFLOW SHEETS OVER CURB

TYPICAL LOT DRAINAGE DETAIL NTS
W/ AREA DRAIN SYSTEM WITHIN PRIVATE SPACE

(LA SUBIDA DR AND REGALADO ST)

EXHIBIT 2 DRAINAGE CONCEPT/HYDROLOGY STUDY FOR ESTU2019000170 PROPOSED CONDITION HYDROLOGY MAP VESTING TENTATIVE TRACT MAP 082160 15405 LA SUBIDA DR., COUNTY OF LOS ANGELES, CA 91745

PLOTTED BY: Gary Guan DATE: Jul. 13, 2020 11:34:40 AM FILE: F:\1038\Engineering\SY_Hydrology\Proposed Hydrology Map.dwg

NOTE: NOT WITHIN COUNTY ADOPTED FLOODWAY—
NOTE: NOT WITHIN FEMA FLOOD ZONA "A"

TREATED FLOW AND HIGH FLOW PIPE

(WITH GRATE INLET INSERTS FOR PRETREATMENTS)

AREA DRAIN AND LOW FLOW PIPE

GRATE INLET FOR WQ FLOWS

PEAK 25-YR FLOW RATE DRAINAGE AREA IN ACRES

SECTION 4 LID AND FILTERRA SIZING CALCUALTIONS

The project will be required to comply with the newly adopted MS4 Permit. This will require all filtration water quality devices to be sized per Adjusted Design Intensity to Provide Additional Capture In Lieu of Volume Reduction (see attached below).

July 2018

Table 6: Adjusted Design Intensity to Provide Additional Capture In Lieu of Volume Reduction (Option B)

	Reliable Infiltration Rate at Site				
Adjusted Time of Concentration (min)	0 in/hr (ET only) Capture Efficiency Target = 93.8%	0.01 in/hr Capture Efficiency Target = 94.1%	0.05 in/hr Capture Efficiency Target = 95.4%	0.15 in/hr Capture Efficiency Target = 98.1%	
	Adjust	ed MWS Design Pre	cipitation Intensitie	s, in/hr	
5	0.55	0.57	0.66	N/A	
7.5	0.51	0.53	0.60	0.96	
10	0.48	0.49	0.57	0.90	
15	0.44	0.45	0.52	0.79	
20	0.41	0.42	0.48	0.74	
30	0.37	0.38	0.43	0.64	
60	0.31	0.31	0.35	0.50	

NA = additional capture is not a viable option to offset volume reduction in these cases.

Per SUSMP flow rate calculations,

$$Q_{PM} = C_D * I_X * A_{Total} * (1.008333 ft_3-hour / acre-inches-seconds)$$

Where:

QPM = Peak Mitigation Flow Rate (cfs)

$$C_D = (0.9 * Imp.) + [(1.0 - Imp.) * C_U]$$

Imp=0.55 for Duplexes Residential, Cu=0.1 per below

$$=0.9*0.55+(1-0.55)*0.1$$

=0.54

Cu= Undeveloped Runoff Coefficient, (0.1 for Soil 16)

Ix = Rainfall Intensity (inches / hour) (per above Table 6 using Infiltration Rate at 0 in/hour, TC per 85th Percentile HydroCalc Calculations)

A_{Total} = Total Area in acres

The LID flow rate calculations can be found from the following table.

LID Filterra Summary Table LA Subida - VTTM 82160 County Of Los Angeles

DMA	Area	TC Calculated	*TC Used	Cd	lx	Орм	Filterra #	Filterra Size	Required Filterra BMP Surface Area	Filterra BMP Surface Area Provided
	(acre)	(Min)	(Min)		(in/hr)	(cfs)			(sf)	(sf)
#1	3.1	33	30	0.54	0.37	0.62	#1	Filterra 8x24	192	192
#2	1.28	37	30	0.54	0.37	0.26	#2	Filterra 7x13	79	91
#3	6.14	52	30	0.54	0.37	1.24	#3	Filterra 12x32	379	384
#4	2.15	33	30	0.54	0.37	0.43	#4	Filterra 8x18	133	144

Note: * Per the Filterra Calculation spreadsheet developed by Contech and Approved by LA County, the maximum applicable TC is 30 minutes for conservative approach, 30 minutes were applied for the TC over 30 minutes.

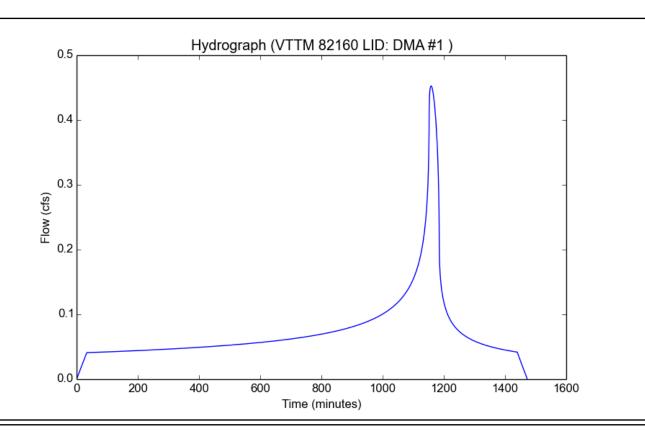
- 1 -

 $\label{location:file_locatio$

Input I	Paramete	ers
---------	----------	-----

Project Name	VTTM 82160 LID
Subarea ID	DMA #1
Area (ac)	3.1
Flow Path Length (ft)	640.0
Flow Path Slope (vft/hft)	0.017
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Jaipat Modalio	
Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2703
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	33.0
Clear Peak Flow Rate (cfs)	0.4525
Burned Peak Flow Rate (cfs)	0.4525
24-Hr Clear Runoff Volume (ac-ft)	0.1522
24-Hr Clear Runoff Volume (cu-ft)	6629.1323
,	

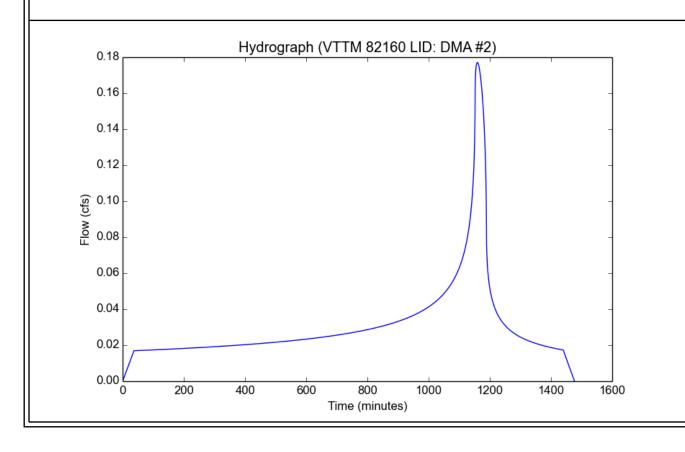


 $\label{location:file_locatio$

Input I	Paramete	ers
---------	----------	-----

Project Name	VTTM 82160 LID
Subarea ID	DMA #2
Area (ac)	1.28
Flow Path Length (ft)	870.0
Flow Path Slope (vft/hft)	0.029
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

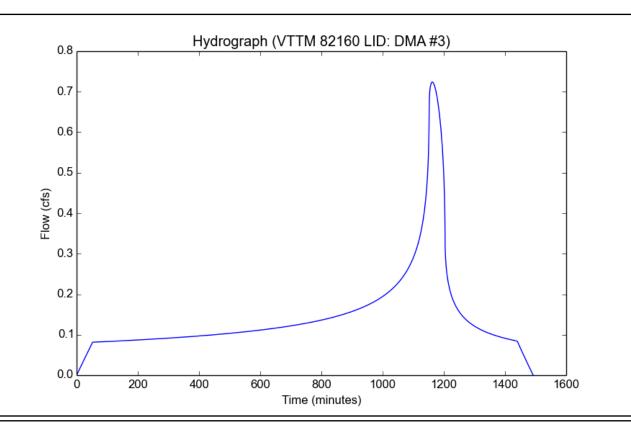
Carpat Rocalio	
Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2562
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	37.0
Clear Peak Flow Rate (cfs)	0.1771
Burned Peak Flow Rate (cfs)	0.1771
24-Hr Clear Runoff Volume (ac-ft)	0.0628
24-Hr Clear Runoff Volume (cu-ft)	2737.2



 $\label{location:file_locatio$

Project Name	VTTM 82160 LID
Subarea ID	DMA #3
Area (ac)	6.14
Flow Path Length (ft)	1325.0
Flow Path Slope (vft/hft)	0.019
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2183
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	52.0
Clear Peak Flow Rate (cfs)	0.7239
Burned Peak Flow Rate (cfs)	0.7239
24-Hr Clear Runoff Volume (ac-ft)	0.3014
24-Hr Clear Runoff Volume (cu-ft)	13130.2355

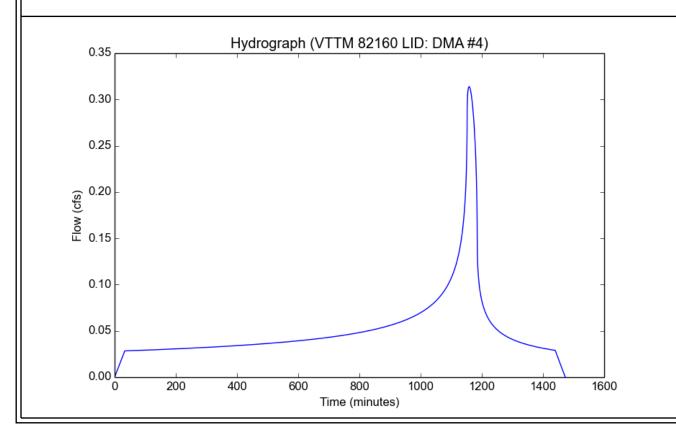


 $\label{location:file_locatio$

Input Parameters

Project Name	VTTM 82160 LID
Subarea ID	DMA #4
Area (ac)	2.15
Flow Path Length (ft)	760.0
Flow Path Slope (vft/hft)	0.034
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2703
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	33.0
Clear Peak Flow Rate (cfs)	0.3139
Burned Peak Flow Rate (cfs)	0.3139
24-Hr Clear Runoff Volume (ac-ft)	0.1055
24-Hr Clear Runoff Volume (cu-ft)	4597.624







<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

	1 1101101 5-15		
Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #1- Filterra #1
Drainage Area Inputs			
Drainage Area		135036	l ft⁴
Runoff coefficient		0.54	<u>-</u>
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in
LA County Rainfall Depth Analysis	,		
Filterra Configuration (Select from D	Prop-Down)	Offline	
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.	
<u>Constants</u>			
LAX Airport 85th Percentile, 24-hour de	oth (for reference only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft²
Outputs			•
Stormwater Quality Design Volume		6,684	ft ³
Design Rainfall Intensity for Equivalent L	ong Term Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		0.58	cfs
Design Alternatives Available		Filterra + Storage Only	
Design Recommendations			
Primary Recommendation - Stand Ald	one Filterra		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		0.62	cfs
Required Filterra Area		192	ft²
Filterra Model ID		FTBSV 8X24	
Alternative Recommendation - Filtern	ra + Infiltration Storage		
Required Filterra Area		181	ft ²
Filterra Model ID		FTBSV 8X23	_
ChamberMaxx volume		0	ft³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name Hunsak	er & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #2- Filterra #2
Drainage Area Inputs			
Drainage Area		55756	1 ft²
Runoff coefficient		0.54	1 .
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyperlink belo	w)	1.10	in
LA County Rainfall Depth Analysis	•		•
Filterra Configuration (Select from Drop-Dow	<u>n)</u>	Offline	
Refer to "Filterra Configurations" tab for description	ons and detail drawings	for download.	=
<u>Constants</u>			_
LAX Airport 85th Percentile, 24-hour depth (for ref	erence only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft ²
<u>Outputs</u>			_
Stormwater Quality Design Volume		2,760	ft ³
Design Rainfall Intensity for Equivalent Long Term	Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		0.24	cfs
Design Alternatives Available		Filterra + Storage Only	_
Design Recommendations			
Primary Recommendation - Stand Alone Filteri	<u>ra</u>		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		0.26	cfs
Required Filterra Area		79	ft ²
Filterra Model ID		FT 7x13 / 13x7	
<u> Alternative Recommendation - Filterra + Infiltr</u>	ation Storage		
Required Filterra Area		75	ft ²
Filterra Model ID		FT 7x13 / 13x7	
ChamberMaxx volume		0	ft ³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

	1 1101101 5 15 1		
Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #3- Filterra #3
Drainage Area Inputs			
Drainage Area		267458	ft⁴
Runoff coefficient		0.54	-
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in
LA County Rainfall Depth Analysis	·		
Filterra Configuration (Select from D	Prop-Down)	Offline	
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.	
<u>Constants</u>			
LAX Airport 85th Percentile, 24-hour de	oth (for reference only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft ²
Outputs			
Stormwater Quality Design Volume		13,239	ft ³
Design Rainfall Intensity for Equivalent I	ong Term Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		1.15	cfs
Design Alternatives Available		Filterra + Storage Only	
Design Recommendations			
Primary Recommendation - Stand Ale	one Filterra		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		1.23	cfs
Required Filterra Area		379	ft²
Filterra Model ID		FTBSV 12X32	
Alternative Recommendation - Filter	ra + Infiltration Storage		
Required Filterra Area		357	ft ²
Filterra Model ID		FTBSV 12X31.5	
ChamberMaxx volume		0	ft ³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #4- Filterra #4
Drainage Area Inputs		<u> </u>	
Drainage Area		93654	ft⁴
Runoff coefficient		0.54	-
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in
LA County Rainfall Depth Analysis			
Filterra Configuration (Select from D	Prop-Down)	Offline	
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.	
<u>Constants</u>			
LAX Airport 85th Percentile, 24-hour dep	oth (for reference only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft ²
<u>Outputs</u>			
Stormwater Quality Design Volume		4,636	ft ³
Design Rainfall Intensity for Equivalent L	ong Term Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		0.40	cfs
Design Alternatives Available		Filterra + Storage Only	
Design Recommendations			
Primary Recommendation - Stand Ald	one Filterra		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		0.43	cfs
Required Filterra Area		133	ft ²
Filterra Model ID		FT 18x8	
Alternative Recommendation - Filtern	a + Infiltration Storage		
Required Filterra Area		125	ft ²
Filterra Model ID		FT 16x8	
ChamberMaxx volume		0	ft ³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

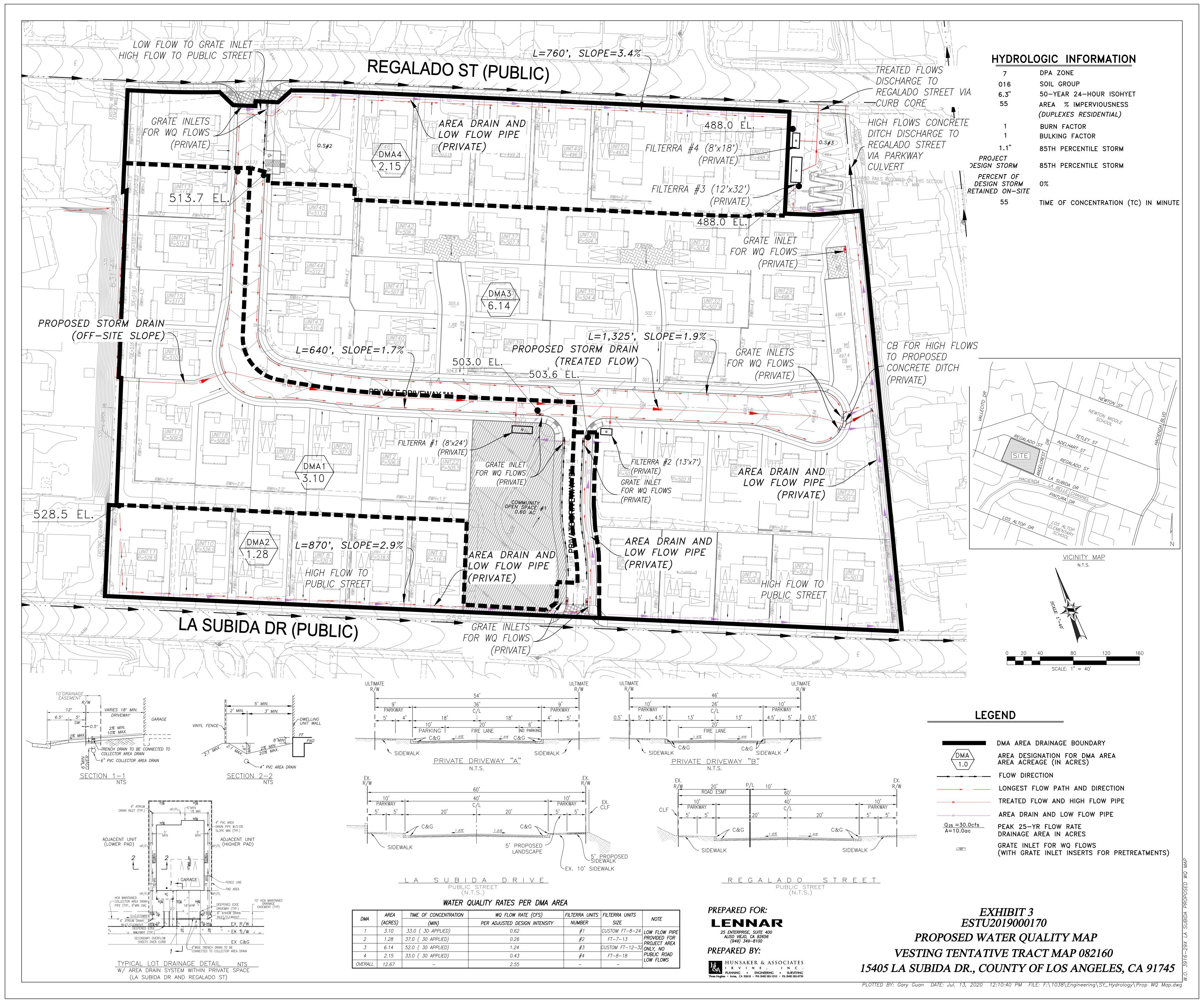
^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

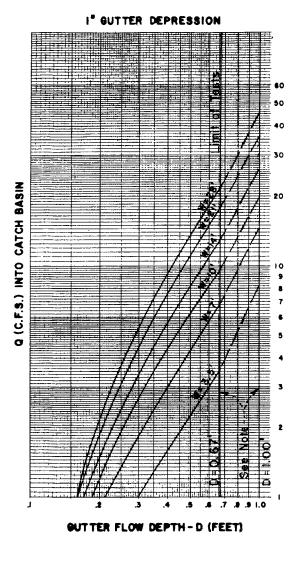
^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.

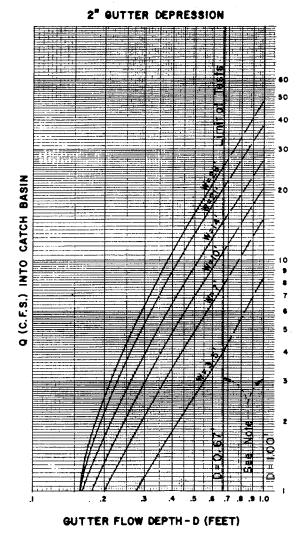


SECTION 5

PRELIMINARY HYDRAULIC UPDATES FOR PD 264, CATCH BASIN, STREET CAPACITY AND CROSS GUTTER CAPACITY CALC'S

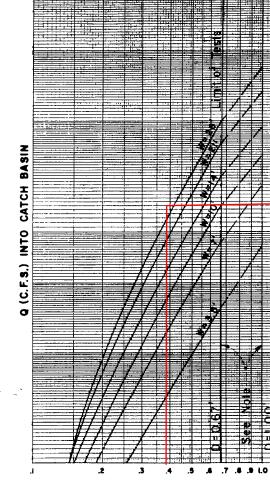
Q = 13.1





NOTE: Curves between D=0.67' and 1.0' are not from model test data and will be revised in the future when additional model test data are available.

Los Jacoles County Flood Control District



4" GUTTER DEPRESSION

GUTTER FLOW DEPTH-D (FEET)

Depth=0.38'

Two Catch Basins with the Sizes of 21-ft and 14-ft (totoal 35-ft)

CURB OPENING CATCH BASIN CAPACITIES

STREET SLOPE = .01

D-10B

Catch Basin along
La Subida Drive

La Subida - Street Capacity

Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

 $\begin{array}{ccc} \text{Channel Slope} & 0.03600 & \text{ft/ft} \\ \text{Discharge} & 13.11 & \text{ft}^3\text{/s} \\ \end{array}$

Section Definitions

Station (ft)		Elevation (ft)	
	0+00		100.67
	0+00		100.00
	0+02		100.13
	0+20		100.45

Roughness Segment Definitions

Start Station		Ending Station	1	Roughness Coefficient	
	(0+00, 100.67)		(0+20, 100.45)		0.015

Options

Current Rougnness Weighted Method
Open Channel Weighting Method
Closed Channel Weighting Method
Pavlovskii's Method
Pavlovskii's Method

Results

Normal Depth		0.38	ft
Elevation Range	100.00 to 100.67 ft		
Flow Area		2.48	ft²
Wetted Perimeter		16.66	ft
Hydraulic Radius		0.15	ft
Top Width		16.28	ft
Normal Depth		0.38	ft
Critical Depth		0.50	ft
Critical Slope		0.00549	ft/ft

	La Subida - Street Capacity
Results	
Velocity	5.29 ft/s
Velocity Head	0.43 ft
Specific Energy	0.82 ft
Froude Number	2.39
Flow Type	Supercritical
GVF Input Data	
Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0
GVF Output Data	
Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.38 ft
Critical Depth	0.50 ft
Channel Slope	0.03600 ft/ft
Critical Slope	0.00549 ft/ft

Cross Section for La Subida - 20' Halfwidth

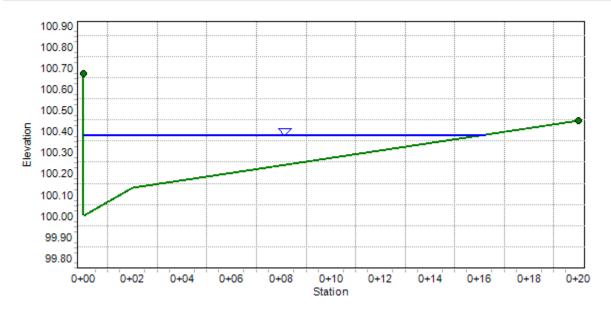
Project Description

Friction Method Manning Formula Solve For Normal Depth

Input Data

0.03600 ft/ft Channel Slope Normal Depth 0.38 ft Discharge 13.11 ft³/s

Cross Section Image



Croos Gutter at Intersection LA Subida and Angelcrest

Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

 $\begin{array}{ccc} \text{Channel Slope} & 0.03700 & \text{ft/ft} \\ \text{Discharge} & 12.52 & \text{ft}^3\text{/s} \end{array}$

Section Definitions

Station (ft)		Elevation (ft)	
	1+00		492.20
	1+16		492.00
	1+19		491.80
	1+43		492.00
	1+71		492.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(1+00, 492.20)	(1+71, 492.5	50) 0.015

Options

Current Rougnness Weighted Method
Open Channel Weighting Method
Closed Channel Weighting Method
Pavlovskii's Method
Pavlovskii's Method

Results

Normal Depth		0.21	ft
Elevation Range	491.80 to 492.50 ft		
Flow Area		2.97	ft²
Wetted Perimeter		28.36	ft
Hydraulic Radius		0.10	ft
Top Width		28.35	ft
Normal Depth		0.21	ft
Critical Depth		0.29	ft

Croos Gutter at Intersection LA Subida and Angelcrest

Results					
Critical Slope		0.00623	ft/ft		
Velocity		4.22	ft/s		
Velocity Head		0.28	ft		
Specific Energy		0.49	ft		
Froude Number		2.30			
Flow Type	Supercritical				
GVF Input Data					
Downstream Depth		0.00	ft		
Length		0.00	ft		
Number Of Steps		0			
GVF Output Data					
Upstream Depth		0.00	ft		
Profile Description					
Profile Headloss		0.00	ft		
Downstream Velocity		Infinity	ft/s		
Upstream Velocity		Infinity	ft/s		
Normal Depth		0.21	ft		
Critical Depth		0.29	ft		
Channel Slope		0.03700	ft/ft		

0.00623 ft/ft

Critical Slope

Cross Section for Cross Gutter Intersection LA Subida and Angelcrest

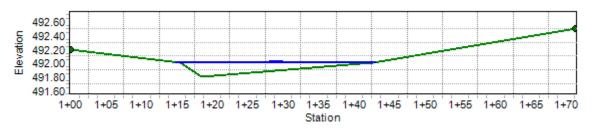
Project Description

Friction Method Manning Formula Solve For Normal Depth

Input Data

0.03700 ft/ft Channel Slope Normal Depth 0.21 ft Discharge 12.52 ft³/s

Cross Section Image



Croos Gutter at Intersection LA Subida and Driveway "B"

Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

 $\begin{array}{ccc} \text{Channel Slope} & 0.03700 & \text{ft/ft} \\ \text{Discharge} & 12.52 & \text{ft}^3\text{/s} \end{array}$

Section Definitions

Station (ft)		Elevation (ft)
	1+00	509.50
	1+13	509.00
	1+19	508.60
	1+71	509.60

Roughness Segment Definitions

Start Station		Ending Station	Roughness Coefficient	
Start Station		Lituing Station	Nougriness Coefficient	
	(1+00, 509.50)	(1+71, 509	9.60)	0.015

0.27 ft

Options

Current Rougnness Weighted Method
Open Channel Weighting Method
Closed Channel Weighting Method
Pavlovskii's Method
Pavlovskii's Method

Results

Normal Depth

Elevation Range	508.60 to 509.60 ft		
Flow Area		2.49	ft²
Wetted Perimeter		18.37	ft
Hydraulic Radius		0.14	ft
Top Width		18.36	ft
Normal Depth		0.27	ft
Critical Depth		0.39	ft
Critical Slope		0.00568	ft/ft

Croos Gutter at Intersection LA Subida and Driveway "B"

Results
Roduito
Velocity 5.03 ft/s
Velocity Head 0.39 ft
Specific Energy 0.66 ft
Froude Number 2.41
Flow Type Supercritical
GVF Input Data
Downstream Depth 0.00 ft
Length 0.00 ft
Number Of Steps 0
GVF Output Data
Upstream Depth 0.00 ft
Profile Description
Profile Headloss 0.00 ft
Downstream Velocity Infinity ft/s
Upstream Velocity Infinity ft/s
Normal Depth 0.27 ft
Critical Depth 0.39 ft
Channel Slope 0.03700 ft/ft
Critical Slope 0.00568 ft/ft

Croos Gutter at Intersection LA Subida and Driveway "B"

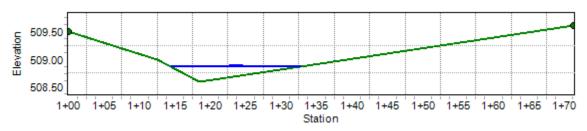
Project Description

Friction Method Manning Formula Solve For Normal Depth

Input Data

0.03700 ft/ft Channel Slope Normal Depth 0.27 ft Discharge 12.52 ft³/s

Cross Section Image



FILE:	epd264	.WSW		W			EDIT LISTI			ISTING	Date:	7-13-20	20 Tir	me: 9:34 PAGE	4:46 1
CARD CODE	SECT NO	CHN TYPE	NO OF AVE PIER/PIP WI	PIER HEIGH DTH DIAME	T 1 BASE TER WIDT		ZR IN		Y(2) Y	(3) Y(4)	Y(5) Y(5) Y(7)	Y(8)	Y(9)	Y(10)
CD	1	4	1	1.500											
CD	2	4	1	2.000											
CD	3	4	1	3.000											
CD	4	4	1	4.000											
CD	5	4	1	3.500											
CD	6	3	0 .0		2.000	.00 W	0 .000 SPGW	.00						PAGE NO	0 1
			W	ATER SURFACE	PROFILE	- TITL	E CARD LIST	ING							
HEADIN	G LINE	NO 1	IS -												
HEADIN	2 T.TNF	NO 2	TC -	Existing PD	264										
IIEADIN	3 LITINE	NO Z	15 -	Hydraulic C	alculatio	ns for	Ex. Storm	Drain at	LA Subid	a and Gler	nstone				
HEADIN	G LINE	NO 3	IS -	nyaraarro c	arcaracio	110 101	Lii. Beoriu	Diain ac	III Babia	a and orei					
				Applying Ex	isting Fl	ows									
						W	SPGW							PAGE NO	2
			W	ATER SURFACE	PROFILE	- ELEM	ENT CARD LI	STING							
ELEME	ON TN	1 IS	A SYSTEM O	UTLET *	*	*									
			U/S DATA	STATION	INVERT	SECT				W	S ELEV				
				8.890	459.720	4					463.720				
ELEME	ON TN	2 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU:	S ANG	LE	ANG PT	MAN H
				27.110	459.790	4		.013			45.001	23.19	3	.000	0
ELEME	ON TN	3 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU	S ANG:	LE	ANG PT	MAN H
				100.110	460.080	4		.013			.000	.00	0	.000	0
ELEME	ON TN	4 IS	A JUNCTION	*	*	*	*		*		*		*		
			U/S DATA	STATION	INVERT	SECT :	LAT-1 LAT-2	N	Q3	Q4	INVERT-3	INVERT-4	PHI 3	3 PHI 4	4
				107.210	460.100	3	3 2	.013	45.000	15.000	460.800	460.8	00 -45	.000	45.000
											RADIU	S ANG:	LE		
											.00	.00	0		
ELEME	ON TN	5 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU	S ANG:	LE	ANG PT	MAN H
				129.740	460.110	3		.013			.000	.00	0	.000	0
ELEME	ON TN	6 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU	S ANG:	LE	ANG PT	MAN H
				154.000	460.120	3		.013			45.000	30.88	9	.000	0
ELEME	NT NO	7 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU	S ANG	LE	ANG PT	MAN H
				169.010	460.460	3		.013			45.001	19.11	1	.000	0
ELEME	ON TN	8 IS	A REACH	*	*	*									
			U/S DATA	STATION	INVERT	SECT		N			RADIU	S ANG:	LE	ANG PT	MAN H
				217.210	462.060	3		.013			.000	.00	0	.000	0
ELEME	ON TN	9 IS	A SYSTEM H	EADWORKS		*			*						
			U/S DATA	STATION	INVERT	SECT				W	S ELEV				
				017 010	160 060	2				4.4	(2, 0, 0, 0				

462.060

217.210 462.060 3

W S P G W - CIVILDESIGN Version 14.08

Program Package Serial Number: 7181

WATER SURFACE PROFILE LISTING

Existing PD 264

FILE: epd264.WSW

Hydraulic Calculations for Ex. Storm Drain at LA Subida and Glenstone Applying Existing Flows

PAGE 1

Date: 7-13-2020 Time: 9:34:49

*****	*****	*****	******	*****	*****	*****	*****	****	*****	****	*****	*****	*****	****	* * *
Station -	Invert Elev 	Depth (FT)	Water Elev 	Q (CFS)	Vel (FPS) 	Vel Head	Energy Grd.El. 	Super Elev 	Depth	Flow Top Width 	DiaFT			No Wt	
L/Elem	Ch Slope ******	 ******	 ******	*****	* * * * * * *	SF Ave	HF	I	Froude N	ı	"N"	X-Fall *****	ZR ****	Type	
8.890	459.720	4.000		69.47	5.53	.47		4.00	2.52	.00	4.000	.000	.00	1	.0
18.220	.0038					.0023	.04	4.00	.00	2.66	.013	.00	.00	PIPE	
27.110	459.790 	4.021	463.811 	69.47	 5.53 	.47	 464.29 	.00 	 2.52 	.00	4.000 	.000	.00	1	.0
12.732	.0040	I – –	-			.0023	.03	4.02	.00	2.63	.013	.00	.00	PIPE	
39.842	459.841 	4.000	463.841 	69.47	5.53 	.47	464.32 	.00	2.52 	.00	4.000	.000	.00	1	.0
60.268	.0040	I I	l			.0022	.13	4.00	.00	2.63	.013	.00	.00	PIPE	
100.110	460.080	3.883	463.963 	69.47		.48		.00	2.52	1.35	4.000	.000	.00	1 -	.0
JUNCT STR	.0028	1			ı	.0011	.01	3.88	.32	1	.013	.00	.00	PIPE	
107.210	 460.100 	4.326		9.47	 1.34 	.03		.00 	 .97 	.00 	3.000 	.000	.00	1	.0
22.530	.0004	- 	- 			.0002	.00	4.33	.00	1.80	.013	.00	.00	PIPE	
129.740		4.321	464.431 	9.47		.03		.00	.97 	.00	3.000	.000	.00	1	.0
24.260	.0004	I I	 			.0002	.00	.00	.00	1.85	.013	.00	.00	PIPE	
154.000	460.120	4.319		9.47	1.34 	.03	464.47	.00	.97 	.00	3.000	.000	.00	1	.0
15.010	.0227	I I	 			.0002	.00	.00	.00	.62	.013	.00	.00	PIPE	
169.010	460.460	3.984	464.444 	9.47	1.34 	.03	464.47	.00	.97 	.00	3.000	.000	.00	1	.0
29.835	.0332	 			ı	.0002	.01	3.98	.00	.57	.013	.00	I	PIPE	
198.845	461.450	3.000	464.450 	9.47	1.34 	.03	464.48 	.00	.97 	.00	3.000	.000	.00	1 -	.0
8.310	.0332	I	ı		ı İ	.0002	.00	3.00	.00	.57	.013	.00	.00	PIPE	

W S P G W - CIVILDESIGN Version 14.08 PAGE 2

Date: 7-13-2020 Time: 9:34:49

Program Package Serial Number: 7181

FILE: epd264.WSW

WATER SURFACE PROFILE LISTING

Existing PD 264

Hydraulic Calculations for Ex. Storm Drain at LA Subida and Glenstone

Applying Existing Flows

******	*****	*****	*****	******	******	******	*****	*****	*****	*****	*****	*****	*****	****	***
	Invert	Depth	Water	Q	Vel	Vel	Energy	Super	Critical	Flow Top	Height/	Base Wt		No W	th
Station	Elev	(FT)	Elev	(CFS)	(FPS)	Head	Grd.El.	Elev	Depth	Width	DiaFT	or I.D.	ZL	Prs/	Pip
-	İ –	j		j -		i		j	j -	j –	j –	i –		İ	
L/Elem	Ch Slope	į		j	·	SF Ave	HF	SE Doth	Froude N	Norm Dp	"N"	X-Fall	ZR	Type	Ch
*****	*****	******	*****	******	*****	*****	*****	*****	******	*****	*****	*****	****	****	* * *
		į		İ	·			İ	İ	İ	İ	j		İ	
207.155	461.726	2.722	464.448	9.47	1.41	.03	464.48	.00	.97	1.74	3.000	.000	.00	1	.0
-					I								_	-	
4.799	.0332	'			'	.0002	.00	2.72	.13	.57	.013	.00	.00	PIPE	
								I	1						
211.954	461.885	2.560	464.446	9.47	1.47	.03	464.48	.00	.97	2.12	3.000	.000	.00	1	.0
-													_	-	
3.938	.0332		•			.0002	.00	2.56	.15	.57	.013	.00	.00	PIPE	
								I	1						
215.892	462.016	2.427	464.443	9.47	1.55	.04	464.48	.00	.97	2.36	3.000	.000	.00	. 1	.0
-													_	-	
1.318	.0332		•			.0002	.00	2.43	.17	.57	.013	.00	.00	PIPE	
								I	1						
217.210	462.060	2.382	464.442	9.47	1.57	.04	464.48	.00	.97	2.43	3.000	.000	.00	. 1	.0
-													-	-	

FILE: 1	PD264.V	ISW			W	W S P ATER SURE				G Versi			NG	Date:	5-19-202	0 Tin	ne:11:50 PAGE):27 1
CARD	SECT	CHN	NO OF Z	AVE PIER					INV					Y(5) Y(5) V(7)	V(8)		
CODE	NO		PIER/PIP		DIAME'			210	DRO		1(2)	1(3)	1(1)	1(3) 1(3) 1(7)	1(0)	1())	1(10)
CODE	110		I IDI(/ I II	WIDIII	DIMI	ILK WID			Dito	_								
CD	1	4	1		1.500													
CD	2	4	1		2.000													
CD	3	4	1		3.000													
CD	4	4	1		4.000													
CD	5	4	1		3.500													
CD	6	3	0		5.000	2.000	.00	00.00	١0	.00								
CD	O	3	U	.000	5.000	2.000		ISPG		.00							PAGE NO) 1
				MATED C	יוום ביא כיבי	PROFILE				NC							PAGE INC	, 1
HEADING	T TNE	NO 1	TC	WAIER S	OKPACE	PROFILE	- 1111	IE CARD	птотт	NG								
UEADIM	2 LINE	NO I	12 -	Erri at	ina DD	264												
HEADIN	T TNTE	NO 2	TC	EXISU	ing PD	204												
HEADIN	3 LINE	NO Z	15 -	IIndo+	المرا المرا	waniia Ga	1 011 0+	iona fa	E	Ctorom	Dwain	+ T 7\ C	rubida	and Clana	_			
HEADING	T TNTE	NTO 2	TC	opuat	.еа пуа.	Laulic Ca	ilculat	JOHS IC	or Ex.	SCOLIII .	Diain a	и па	ubiua	and Glens	L			
HEADIN	3 LINE	NO 3	15 -															
							τ.	I S P G	T-7								PAGE NO) 2
				MARIED O	TID DA CD	DDOELLE				штыс							PAGE NO)
	ATEL ATO	1 -	C & CYCHEN		*	PROFILE,			KD LT2	TING								
ELEMEI	NI NO	т т	S A SYSTEM		TION	INVERT							747	S ELEV				
			U/S DA				SECI 4						W					
	ATEL ATO	О Т	C A DEAGH		8.890	459.720	. 4							463.720				
ELEMEI	N.I. NO	2 I	S A REACH			**************************************	, andm	•						DADIII	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	_	ANG DE	N/23T TT
			U/S DA		TION	INVERT				N 012				RADIU			ANG PT	
DT DMD	ATTIL ATO	Э. Т	G 3 DE3GH	2	27.110	459.790	4			.013				45.001	23.198	5	.000	0
ELEMEI	N.I. NO	3 I	S A REACH					•						DADIII	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	_	ANG DE	N/23T TT
			U/S DA		TION	INVERT	SECT			N 012				RADIU			ANG PT	
DT DMD	ATTIL ATO	4 -	G 3 TIMOTT		00.110	460.080	. 4			.013	*			.000	.000) *	.000	0
ELEMEI	N.I. NO	4 I	S A JUNCTI					` ^ T	7 E O				. 4		TATTEDE 4) DIII	1
			U/S DA		TION	INVERT		LAT-1 I		N	Q3	_	24	INVERT-3				
				10	7.210	460.100	3	3	2	.013	45.00	10 1	L5.000	460.800	460.80		.000 4	15.000
														RADIU				
DT DMD	ATTIL NTO		a a beacu		*		. ,							.00	000.)		
ELEMEI	N.I. NO	5 I	S A REACH			7 T T T T T T T T T T T T T T T T T T T								DADIII	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	_	ANG DE	N4737 II
			U/S DA		TION	INVERT				N				RADIU			ANG PT	
		с т	a	12	29.740	460.110	. 3	_		.013				.000	.000)	.000	0
ELEMEI	N.I. NO	6 I	S A REACH					•								_		
			U/S DA		TION	INVERT	SECT			N				RADIU			ANG PT	
		-		15	4.000	460.120	3			.013				45.000	30.889	,	.000	0
ELEMEI	N.I, NO	./ I	S A REACH		*			•								_		
			U/S DA		TION	INVERT	SECT			N				RADIU			ANG PT	MAN H
		_		16	9.010	460.460	3			.013				45.001	19.111	-	.000	0
ELEMEI	NT NO	8 I	S A REACH		*	7		•										
			U/S DA		TION	INVERT	SECT			N				RADIU			ANG PT	
						462.060	3			.013				.000	.000)	.000	0

W S ELEV

462.060

ELEMENT NO

9 IS A SYSTEM HEADWORKS U/S DATA

STATION

217.210 462.060

INVERT SECT

FILE: PD264.WSW Program Package Serial Number: 7181

WATER SURFACE PROFILE LISTING

Existing PD 264

Updated Hydraulic Calculations for Ex. Storm Drain at LA Subida and Glen

PAGE 1

Date: 5-19-2020 Time:11:50:31

*****	******	st ******	* * * * * * * * * * * *	******	******	******	*****	*****	*****	*****	*****	******	****	*****	·**
Station	Invert Elev	Depth (FT)	Water Elev	Q (CFS)	Vel (FPS)	Vel Head	Energy Grd.El.	Elev	Critical Depth		Height/ DiaFT		ZL	No Wt Prs/P	
L/Elem *****	 Ch Slope ******		- ******	*****	I	SF Ave	HF		- Froude N *****		 "N" *****	 X-Fall *****	ZR ****	 Type ****	
8.890	459.720	4.000	 463.720 	72.50	5.77 	.52 	464.24	4.00	2.58	.00 	4.000	.000	.00	 1 -	.0
18.220	.0038	- 	-			.0025	.05	4.00	.00	2.74	.013	 .00		- PIPE 	
27.110	459.790	4.029	463.819 	72.50	5.77 	.52	464.34	.00	2.58	.00 	4.000	.000 	.00	1 -	.0
20.274	.0040	I I	l		 	.0025	.05	4.03		2.71	.013	.00 		PIPE	
47.384	459.871	4.000	463.871 	72.50	5.77 	.52	464.39	.00	2.58	.00	4.000	.000 	.00	' -	.0
52.726	.0040	I I	l		 	.0024	.13	4.00	.00	2.71	.013	.00 		PIPE	
100.110	460.080	3.910	463.990 	72.50	5.80	.52	464.51	.00	2.58	1.19 	4.000	.000 	.00	' -	.0
JUNCT STR	.0028			'	 	.0013	.01	3.91	.32	' 	.013	.00 	.00	PIPE	
107.210	460.100	4.361	464.461 	12.50	1.77	.05	464.51	.00 	1.12	.00	3.000	'.000' 	.00	' -	.0
22.530	.0004		' 			.0004	.01	4.36	.00	2.21	.013	.00 		PIPE	
129.740	460.110	4.359	464.469 	12.50	1.77	.05	464.52	.00 	1.12	.00	3.000	'.000' 	.00	' -	.0
24.260	.0004	<u>'</u>	' 			.0004	.01	.00	.00	2.27	.013	.00 	.00	PIPE	
154.000	460.120	4.363	464.483	12.50	1.77	.05	464.53	.00	1.12	.00	3.000	.000 	.00	' -	.0
15.010	.0227		' 		ı	.0004	.01	.00	.00	.71	.013	.00 		PIPE	
169.010	460.460	4.033	464.492 	12.50	1.77	.05	464.54	.00 	1.12	.00	3.000	.000 	.00	' -	.0
31.437	.0332			,		.0003	.01	4.03	.00	.65	.013	.00 	.00	PIPE	
200.447	461.504	3.000	464.504 	12.50	1.77	.05	464.55	.00	1.12	.00 	3.000	.000 	.00	' -	.0
8.283	.0332	ı	·	'	. I	.0003	.00	3.00	.00	.65	.013	.00	.00	PIPE	

W S P G W - CIVILDESIGN Version 14.08 PAGE 2

Program Package Serial Number: 7181

WATER SURFACE PROFILE LISTING Date: 5-19-2020 Time:11:50:31

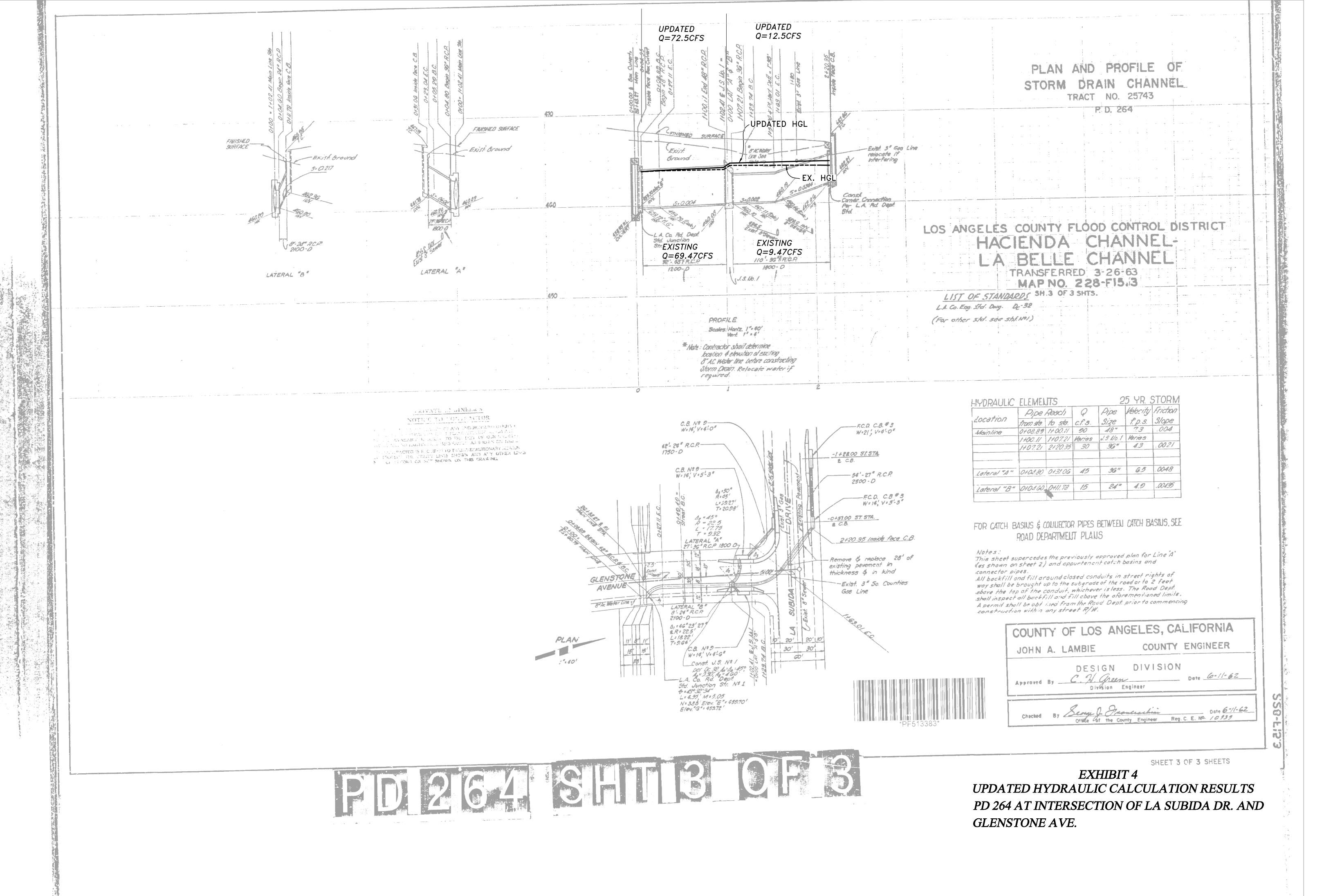
Existing PD 264

Updated Hydraulic Calculations for Ex. Storm Drain at LA Subida and Glen

S

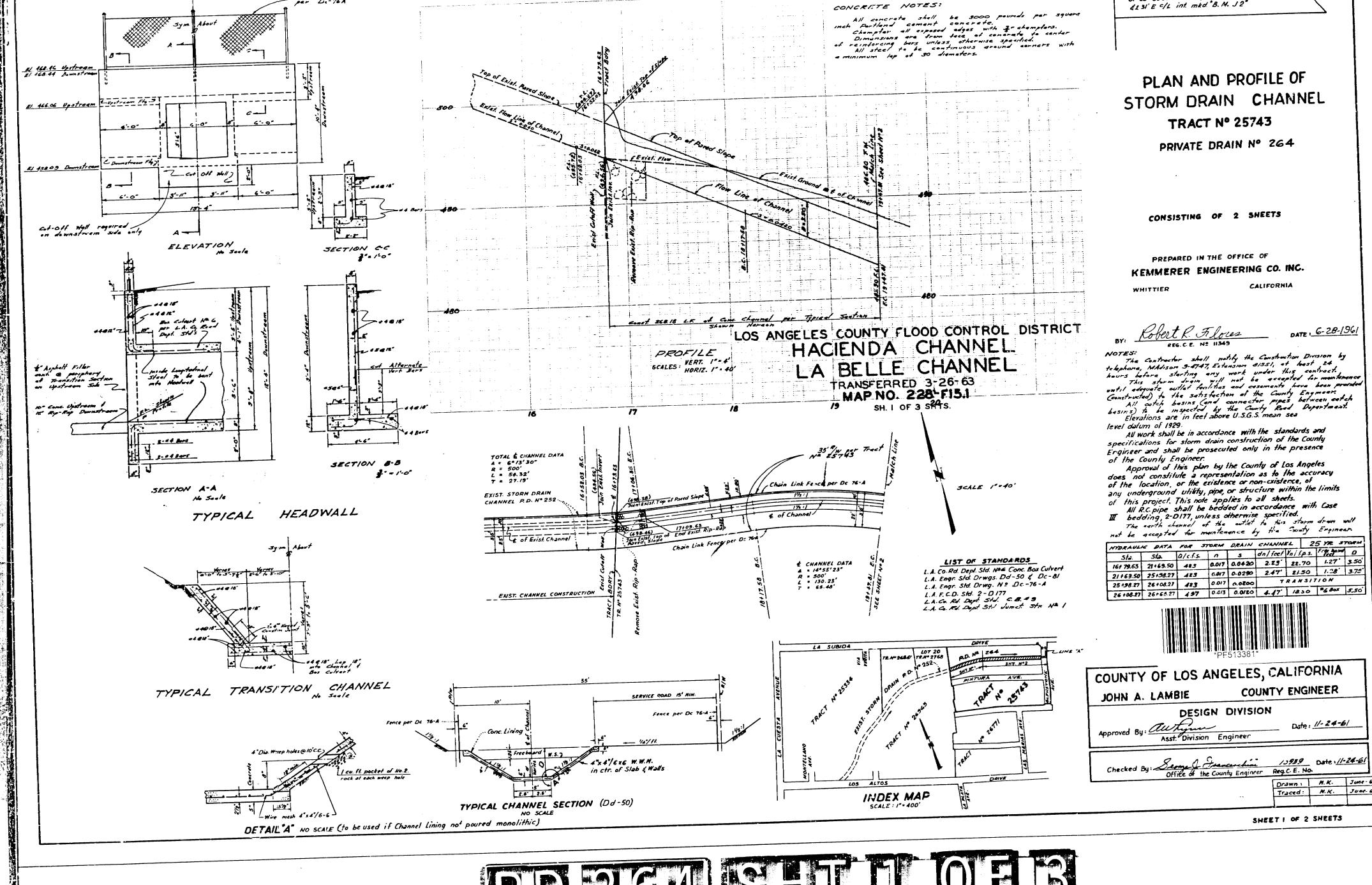
FILE: PD264.WSW

******	*****	******	*****	******	******	******	*****	****	*****	*****	*****	*****	*****	*****	*
	Invert	Depth	Water	Q	Vel	Vel	Energy	Super	Critical	Flow Top	Height/	Base Wt		No Wth	
Station	Elev	(FT)	Elev	(CFS)	(FPS)	Head	Grd.El.	Elev	Depth	Width	DiaFT	or I.D.	ZL	Prs/Pip	р
-															
L/Elem	Ch Slope	[SF Ave	HF		Froude N		"N"	X-Fall	ZR	Type Cl	
******	*****	******	*****	*******	*****	*****	******	*****	******	******	******	******	****	*****	*
208.729	461.778	2.722	464.500	12.50	1.85	.05	464.55	.00	1.12	1.74	3.000	.000	.00	1 .0	0
-													_	-	
4.750	.0332					.0003	.00	2.72	.17	.65	.013	.00	.00	PIPE	
213.479	461.936	2.560	464.497	12.50	1.95	.06	464.56	.00	1.12	2.12	3.000	.000	.00	1 .0	0
-													-	-	
3.731	.0332					.0003	.00	2.56	.20	.65	.013	.00	.00	PIPE	
217.210	462.060	2.432	464.492	12.50	2.04	.06	464.56	.00	1.12	2.35	3.000	.000	.00	1 .0	0
-													-	-	



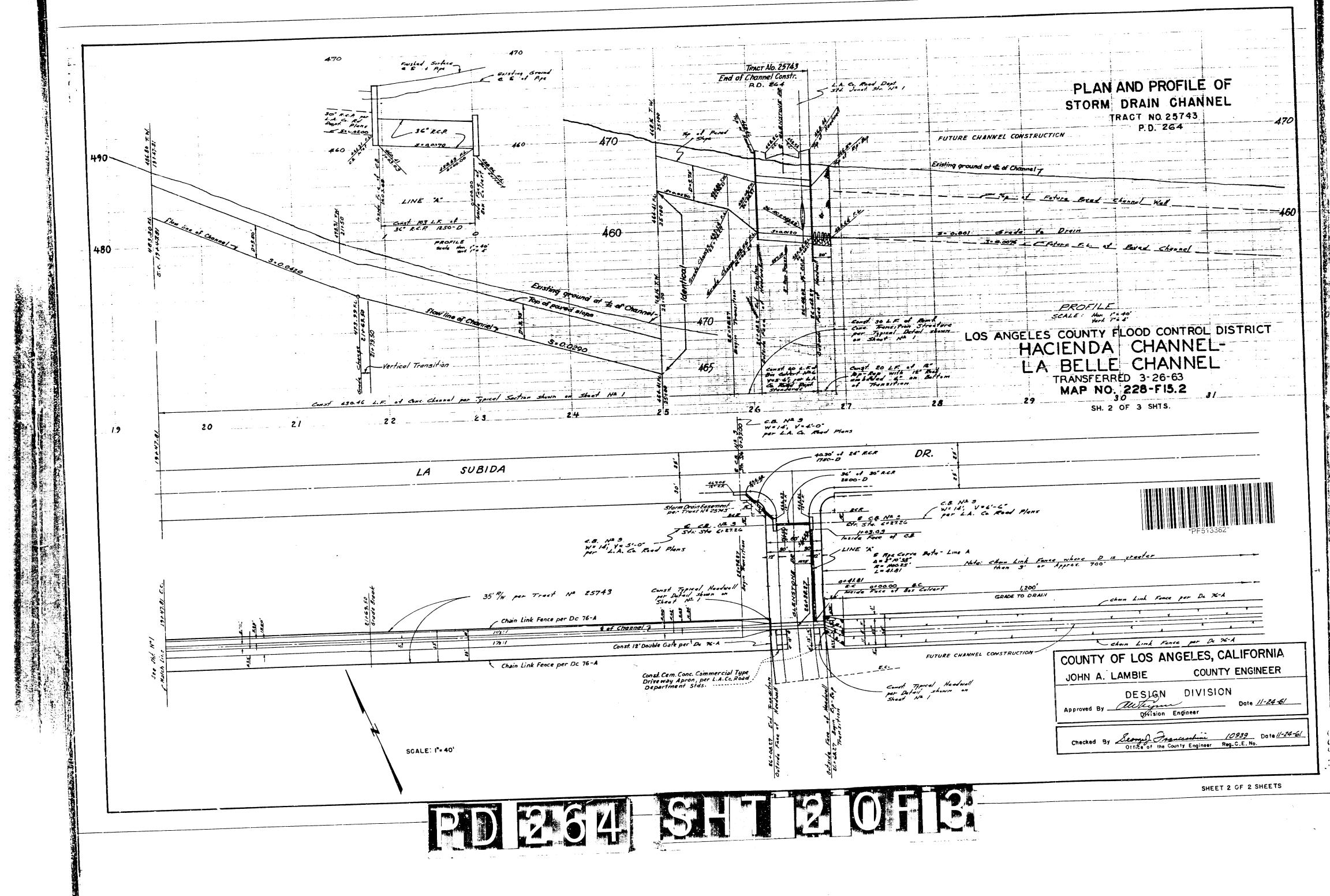
SECTION 6 REFERENCES

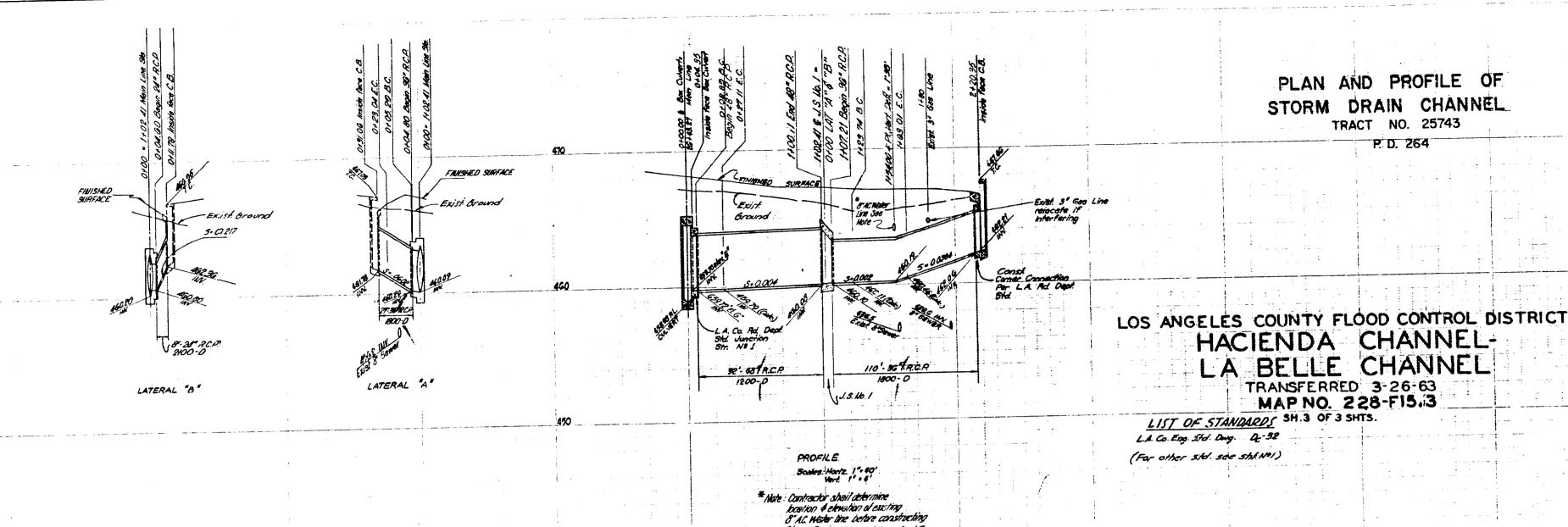
•	EXISTING	STORM DRAIN PD264
•		



PD264 SFIIIOFS

B.M. S.G.1609 - ELEV. 563.121
LEBN. in S.W. cor. of weir box at N.E. cor.
of La Cuesta Ave. & La Subida Dr. ± 27' N.
4±31' E =/L int. mkd. B.M. J 2"

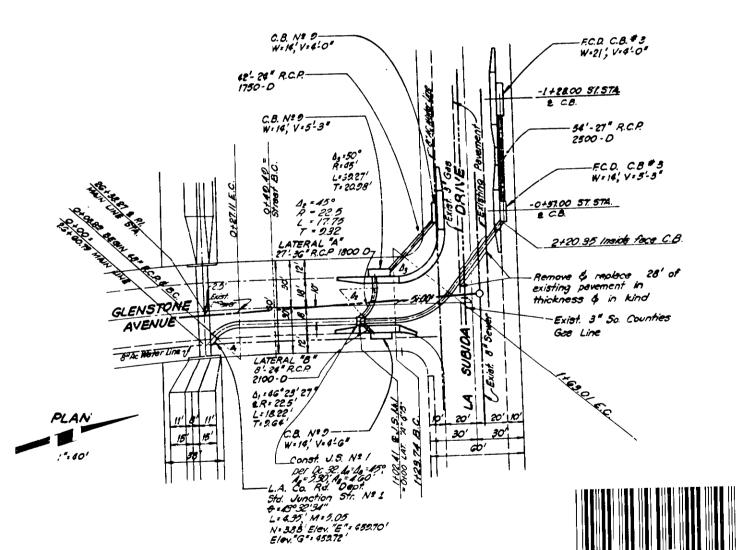




NOTICE TO COTTANACTOR

NOTICE TO COTTANACTOR

TO THE STANDARD OF ANY UNDERGRAND BRIDGY OF THE STANDARD OF THE STANDARD OF ANY UNDERGRAND BRIDGY OF ALL AND ADDRESS OF THE STANDARD OF THE STANDARD STANDARD OF THE STANDARD OF



Storm DIONT. Relocate water if

"YDRAULIC		Awc/i	Q	Pipe	Hobsity	Friction
Location	from sto.		c.f.s.	Size	P.D.S.	3/ope
Mainline	0+08.89		90	48"	73	.004
	1+00.11	1+07.21	Hories	J.S. No.1	KATIBS	
	1107.21	2+20.35	30	36"	4.3	.0021
Lateral "A"	0+01.80	0+31.06	45	36"	6.5	.0048
Lateral "B"	010100.	0411.78	15	24"	1.0	.00135

FOR CATCH BASINS & CONNECTOR PIPES BETWEEN CATCH BASINS, SEE ROAD DEPARTMENT PLANS

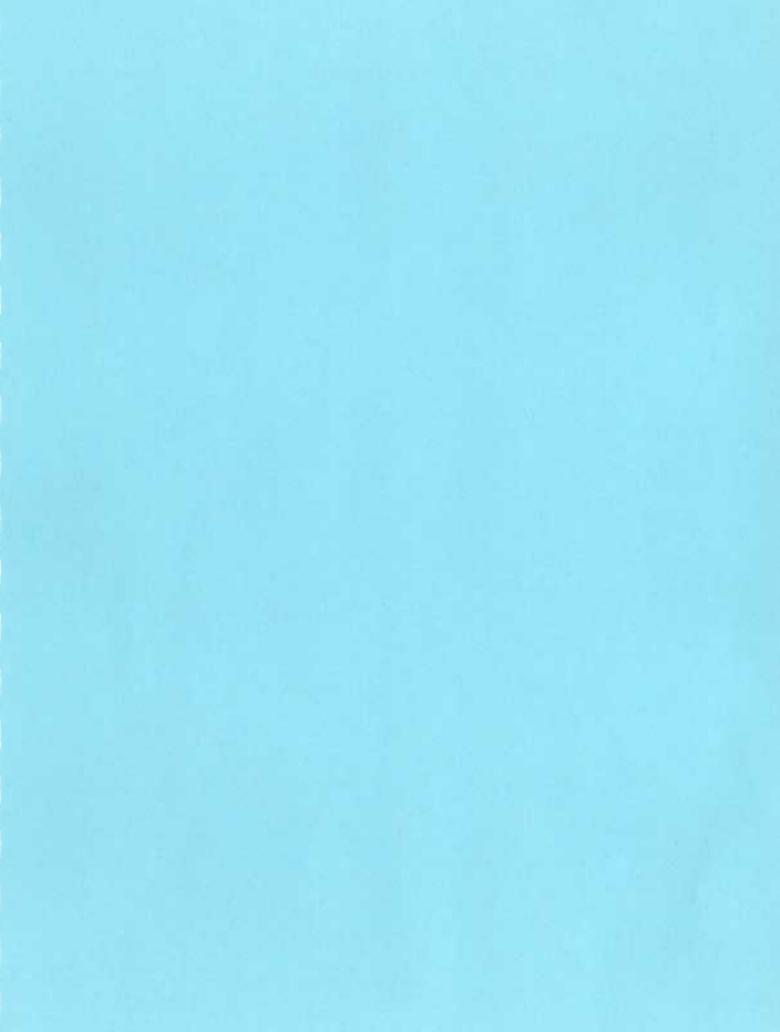
Notes:
This sheet supercedes the previously approved plan for Line A (les shown on sheet 2) and appurtenent catch basins and connector pipes.
All backfill and fill around closed conduits in street rights of way shall be brought up to the subgrade of the road or to 2 feet above the top of the conduit, whichever is less. The Road Dept. shall inspect all backfill and fill above the aforementioned limits. A permit shall be obtined from the Road Dept. prior to commencing construction within any street R/W.

COUNT	Y	OF LOS	ANGELES, CA	
JOHN	A.	LAMBIE	COUNTY	ENGINEER
		DESIG	N DIVISION	
Approved	Ву	C. H. G.	n Engineer	Date 6-11-62

SHEE

ED264 SHIB OF S

SHEET 3 OF 3 SHEETS



• RWQCB APPROVAL LETTER





Los Angeles Regional Water Quality Control Board

Date: August 7, 2019

Paul Alva Assistant Deputy Director County of Los Angeles Dept. of Public Works 900 South Fremont Avenue Alhambra, CA 91803 VIA EMAIL ONLY

APPROVAL OF ALTERNATIVE BIOFILTRATION SPECIFICATION PURSUANT TO PART VI.D.7.c.iii.(1)(b)(i) OF THE LOS ANGELES COUNTY MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) PERMIT (NPDES PERMIT NO. CAS004001; ORDER NO. R4-2012-0175 AS AMENDED BY STATE WATER BOARD ORDER WQ 2015-0075 AND LOS ANGELES WATER BOARD ORDER R4-2012-0175-A01)

Dear Mr. Alva:

On June 5, 2019 the Los Angeles Regional Water Quality Control Board (Los Angeles Water Board) received a letter from the County of Los Angeles (County) requesting approval for the use of Bio Clean Modular Wetlands System (MWS Linear) manufactured by Bio Clean as an alternative biofiltration design specification.

The County's request includes an attachment, entitled "Equivalency Analysis and Design Criteria for Modular Wetlands Systems" (Equivalency Analysis), that details a proposed design approach and equivalency criteria for MWS Linear installations to achieve equivalent performance to the biofiltration design specifications defined in the Los Angeles County MS4 Permit.

Pursuant to Part VI.D.7.c.iii.(1)(b)(i) of the Los Angeles County MS4 Permit, projects using biofiltration as an alternative compliance measure may use alternative design specifications for on-site biofiltration systems if approved by the Los Angeles Water Board Executive Officer.

Background

Part VI.D.7 of the Los Angeles County MS4 Permit requires Permittees to implement a Planning and Land Development Program. As part of this program, Permittees shall require all New Development and Redevelopment projects identified in Part VI.D.7.b (hereinafter "new projects") to control pollutants, pollutant loads, and runoff volume emanating from the project site. Except as provided in Part VI.D.7.c.ii (Technical Infeasibility or Opportunity for Regional Ground Water Replenishment), Part VI.D.7.d.i (Local Ordinance Equivalence), or Part VI.D.7.c.v (Hydromodification), each Permittee shall require new projects to retain on-site the Stormwater Quality Design Volume (SWQDv).

IRMA MUÑOZ, CHAIR | RENEE PURDY, EXECUTIVE OFFICER

Pursuant to Part VI.D.7.c.iii.(1) of the Los Angeles County MS4 Permit, Permittees may allow new projects to use on-site biofiltration when the project applicant has demonstrated that it is technically infeasible to retain 100 percent of the Stormwater Quality Design Volume (SWQDv) on-site. If a Permittee conditions a project using biofiltration due to demonstrated technical infeasibility, then the new project must biofiltrate 1.5 times the portion of the SWQDv that is not reliably retained on-site, as calculated by the following equation:

$$Bv = 1.5 [SWQDv - Rv]$$

Where:

Bv = biofiltration volume

SWQDv = the stormwater runoff from a 0.75 inch, 24-hour storm or the 85^{th}

percentile storm, whichever is greater Rv = volume reliably retained on-site.

As a condition for on-site biofiltration, bioretention/biofiltration systems shall meet the design specifications provided in Attachment H of the Los Angeles County MS4 Permit unless otherwise approved by the Los Angeles Board Executive Officer.

Public Review

On June 20, 2019, the Los Angeles Water Board provided public notice and a 30-day period to allow for public review and written comment on the proposed use of the Bio Clean Modular Wetlands System alternative biofiltration design specification. No comments were received.

Alternative Biofiltration Specification Approval

I hereby approve the County's proposal for the use of the MWS Linear as an alternative on-site biofiltration design specification pursuant to Part VI.D.7.c.iii(1)(b)(i) of the Los Angeles County MS4 Permit, provided the following conditions are met:

- 1. **Vegetative Treatment**: Systems must include vegetation and must be designed such that there is effective treatment due to vegetation (e.g. uptake, chemical transformation, transpiration, treatment from associated microbial activity, etc.).
- 2. **Review**: The County shall ensure that the data relied upon and the conclusions presented in the Equivalency Analysis are appropriate.
- 3. **Sizing:** Systems must be designed and sized following the methodology in Section 4 of the July 2018 Equivalency Analysis document.
- O&M: Operation and maintenance of the MWS Linear must be conducted consistent with the recommendations in the maintenance manual provided by the manufacturer and any revisions thereto.
- 5. **Media**: MWS Linear proprietary media must be provided by the manufacturer. No substitution of these materials/media is allowed.

6. Hydromodification: There is no presumption by this approval that a Permittee's implementation of the abovementioned design parameters and use specifications of the MWS Linear system meet the separate hydromodification requirements of Part VI.D.7.c.iv of the Los Angeles County MS4 Permit. Hydromodification requirements apply regardless of the type of biofiltration system used.

This approval only applies to the use of MWS Linear as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site. Furthermore, this approval does not constitute certification or verification of the performance of the MWS Linear since the Los Angeles Water Board does not have a testing and certification program for treatment control BMPs. This approval is given based on the supporting documentation provided in the request and relies on the County's review of the system.

The County shall comply with Maintenance Agreement and Transfer requirements outlined in Part VI.D.7.d.iii of the Los Angeles County MS4 Permit. These requirements include:

- Part VI.D.7.d.iii prior to issuing approval for final occupancy, the County shall require new
 development and redevelopment projects subject to post-construction BMP requirements to
 provide an operation and maintenance plan; monitoring plan, where required; and verification of
 ongoing maintenance provisions for LID practices, treatment control BMPs, and
 hydromodification control BMPs.
- 2. Part VI.D.7.d.iii.(1)(a) verification of post-construction BMP maintenance agreement shall include all the documents included in this provision.
- 3. Part VI.D.7.d.iii.(1)(b) the County shall ensure a plan is developed for the operation and maintenance of all structural and treatment controls. The County shall examine the plan for relevance to keeping the BMPs in proper working order. Furthermore, operation and maintenance plans for private BMPs shall be kept on-site for periodic review by County inspectors.
- 4. Part VI.D.7.d.iv.(c) the County shall verify proper maintenance and operation of post-construction BMPs operated by the County.
- 5. Part VI.D.7.d.iv.(d) for post-construction BMPs operated and maintained by parties other than the County, the County shall require the other parties to document proper maintenance and operations.
- 6. Part VI.D.7.d.iv.(e) the County shall undertake any enforcement as appropriate per the established progressive enforcement policy.

If you have any questions, please contact Ms. Susana Vargas of the Storm Water Permitting Unit at Susana.Vargas@waterboards.ca.gov or by phone at (213) 576-6688. Alternatively, you may also contact lvar Ridgeway, Chief of the Storm Water Permitting Unit, at lvar.Ridgeway@waterboards.ca.gov or by phone at (213) 620-2150.

Sincerely,

Renee Purdy

Executive Officer



DRAINAGE CONCEPT/ Hydrology study

ESTU2019000170

"La Subida"

Vesting Tentative Tract Map No. 82160 15405 La Subida Drive

County of Los Angeles



DRAINAGE CONCEPT/HYDROLOGY STUDY **ESTU2019000170 " La Subida"** | Vesting Tentative Tract Map No. 82160 | 15405 La Subida Drive

County of Los Angeles



LOW IMPACT DEVELOPMENT PLAN ESTU2019000170

LA SUBIDA – TRACT NO. 82160

Project Address: 15405 Regalado Street Los Angeles County, CA

Prepared for:

LENNAR®

15131 Alton Parkway, Suite 365 Irvine, CA 92618

Prepared by:
Hunsaker & Associates Irvine, Inc.
3 Hughes
Irvine, CA 92618
(949) 583-1010



Preparation Date: February 15, 2019 Revision Date: July 13, 2020

LOW IMPACT DEVELOPMENT PLAN "LA SUBIDA" — VITM 82160 LOS ANGELES COUNTY, CA

LOW IMPACT DEVELOPMENT (LID) PLAN

"LA SUBIDA" VESTING TENTATIVE TRACT MAP NO. 82160

15405 REGALADO STREET

Community of Hacienda Heights County of Los Angeles, California

PREPARED FOR:



15131 ALTON PARKWAY, SUITE 365 IRVINE, CA 92618

> SUBMITTED TO: COUNTY OF LOS ANGELES 900 S. FREMONT AVENUE ALHAMBRA, CA 91803 (626) 458-5100

> > PREPARED BY:



HUNSAKER & ASSOCIATES IRVINE, INC. 3 HUGHES IRVINE, CA 92618 (949) 583-1010

FEBRUARY 15, 2019 REVISED: SEPTEMBER 16, 2019; MAY 29, 2020; JULY 13, 2020

Engineer's Certification Low Impact Development (LID) Plan

Preparer (Engineer) Certification						
Preparer (Engineer): Shawn Yu						
Title	Project Engineer	PE Registration #	C87239			
Company	Hunsaker & Associates Irvine, Inc.					
Address	3 Hughes, Irvine, CA 92618					
Email	syu@hunsaker.com					
Telephone #	949-583-1010					

I HEREBY CERTIFY THAT THIS LOW IMPACT DEVELOPMENT (LID) PLAN IS IN COMPLIANCE WITH THE REQUIREMENTS SET FORTH IN ORDER NO. R4-2012-0175/NPDES NO. CAS004001 OF THE LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD.

I certify under penalty of law that this document and all attachments were prepared under my jurisdiction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, to the best of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations

Preparer Signature	Date
Place Stamp Here	C87239 COVIL OF CALIFORNIA CIVIL OF CALIFORNIA

Table of Contents

Section	Page
LID NOTES:	i
	1
B. Designated Project Categories	
	3
,	3
F. Watershed Area and Drainage Condit.	ions 4
G. Other Site Considerations	4
H. Receiving Water Impairments	5
	6
II. BEST MANAGEMENT PRACTICES (BMP's).	7
A. Site Design Principles	
D. Storm Water Quality Design Volume (S	SWQDv)10
	s10
III. Storm Water Quality Control Measure Main	ntenance12
ATTACHMENTS	33
ATTACHMENT A VICINITY MAP	34
	35
	DETAILS36
	ICE PLAN39
ATTACHMENT E BMP INSPECTION MAINTEN	JANCE RECORDS44
ATTACHMENT F EDUCATIONAL MATERIALS	45
ATTACHMENT G RWQCB APPROVAL LETTER	46

LID NOTES:

1. Determine and provide the pre and post development pervious and impervious areas created by the proposed development.

-				
7.12	Acres	Percent Impervious _	55	%
5.82	_ Acres	Percent Pervious _	45	_ %
10.74	Acres	Percent Impervious _	83	<u></u> %
2.2	Acres	Percent Pervious	17	%
	7.12 5.82 10.74	7.12 Acres 5.82 Acres	7.12 Acres Percent Impervious 5.82 Acres Percent Pervious 10.74 Acres Percent Impervious	7.12AcresPercent Impervious555.82AcresPercent Pervious4510.74AcresPercent Impervious83

- 2. Any modifications to the approved Low Impact Development (LID) report must be resubmitted to the County for approval.
- 3. A copy of the approved Low Impact Development (LID) report must be in the possession of a responsible person and available at the site at all times.
- 4. All structural BMP's shall be accessible for inspection and maintenance.
- 5. Prior to commencement of any work for connection to County maintained storm drain, an encroachment permit from L.A. County Construction Division, Permit Section is required (626) 458-3129.
- 6. Prior to commencement of any work and/or discharge of drainage to a jurisdictional watercourse, a permit from both the California Department of Fish and Game and U.S. Army Corps of Engineers may be required.

I. LID Requirements and Project Description

A. LID Background

In 1987, The Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA] was amended to provide that the discharge of pollutants to waters of the United States from stormwater is effectively prohibited, unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) Permit. The 1987 amendments to the CWA added Section 402 (p), which established a framework for regulating municipal, industrial and construction stormwater discharges under the NPDES program. In California, these permits are issued through the State Water Resources Control Board – (SWRCB) and the nine Regional Water Quality Control Boards.

On November 8, 2012, the Regional Water Quality Control Board, Los Angeles Region (RWQCB), adopted Order No. R4-2012-0175. This Order is the NPDES Permit (NPDES No. CAS004001) for municipal stormwater and urban runoff discharges within the County of Los Angeles.

As adopted in November 2012, the requirements of Order No. R4-2012-0175 (the "Permit") cover 84 cities and the unincorporated areas of Los Angeles County. The County of Los Angeles and the 84 incorporated cities are designated as Permittees.

In compliance with the Permit, the Permittees have implemented a stormwater quality management program (SQMP) with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff wherein new development/redevelopment projects are required to prepare a Low Impact Development (LID) report.

As a Permittee of the County of Los Angeles, Best Management Practices (BMPs) are enforceable by the Community of Hacienda Heights.

B. Designated Project Categories

Table 1, Designated Project Categories, identifies the Project as Category 1, thereby requiring development of this Low Impact Development (LID) report.

	Table 1 – Designated Project Categories				
Category	Description				
1	All development projects equal to 1 acre or greater of disturbed area and adding more than 10,000 square feet of impervious surface area.				
2	Industrial parks with 10,000 square feet or more of surface area.				
3	Commercial malls with 10,000 square feet or more of surface area.				
4	Retail gasoline outlets with 5,000 square feet or more of surface area.				
5	Restaurants (Standard Industrial Classification [SIC] of 5812) with 5,000 square feet or more of surface area.				
6	Parking lots with 5,000 square feet or more of impervious surface area, or with 25 or more parking spaces.				
7	Automotive service facilities (SIC Codes: 5013, 5014, 5511, 5541, 7532-7534 and 7536-7539) with 5,000 square feet or more of surface area.				

Table 1 – Designated Project Categories					
Category	Description				
8	Projects located in or directly adjacent to, or discharging directly to a Significant Ecological Area (SEA), where the development will: • Discharge stormwater runoff that is likely to impact a sensitive biological species or habitat; and • Create 2,500 square feet or more of impervious surface area.				
9	Redevelopment projects, which are developments that result in creation or addition or replacement of either: 5,000 square feet or more of impervious surface on a site that was previously developed as described in the above bullets; or (2) 10,000 square feet or more of impervious surface area on a site that was previously developed as a single family home. • Where 50 percent or more of the impervious surface of a previously developed site is proposed to be altered and the previous development project was not subject to post-construction stormwater quality control measures, the entire development site (e.g., both the existing development and the proposed alternation) must meet the requirements of the LID Standards Manual. • Where less than 50% of the impervious surface of a previously developed site is proposed to be altered and the previous development project was not subject to post-construction stormwater quality control measures, only the proposed alteration must meet the requirements of the LID Standards Manual. • Redevelopment does not include routine maintenance activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of facility or emergency redevelopment activity required to protect public health and safety. Impervious surface replacement, such as the reconstruction of parking lots and roadways which does not disturb additional area and maintains the original grade and alignment, is considered a routine maintenance activity. Redevelopment does not include the repaving of existing roads to maintain original line and grade.				

C. Site Description

The project is located at the northwest intersection of La Subida Drive and Angelcrest Drive, in the Community of Hacienda Heights. The project address is 15405 Regalado Street, Hacienda Heights, CA 91745. The APN's are 8222-009-900, -901, -902.

Surrounding land use include primarily residential land uses on all sides, including Regalado Street to the north, Angelcrest Drive to the east, La Subida Drive to the south and Cardillo Avenue to the west.

Existing land use for the project site is an Elementary School that consists of classroom buildings, surface parking, playground and open spaces areas.

D. Project Description

LENNAR proposes Vesting Tentative Tract Map No. 82160 for the development of 52 detached single family residential, parking, private drives, curb, gutter, sidewalk and storm drain improvements, retaining walls, wet and dry utilities and related infrastructure improvements.

٨			• • •	•	•		•	- 1	(II ·	
А	conceptual	residential	unit	mıx	ıs	provided	ın	the	tollowing	table
, ,	concopioai	rosiacimai	OTTI	11111	10	provided		1110	101101111119	IGDIC

Plan Type	Living Area (sf)	Bed/Bath	Mix	Percentage
1	3,893	5/4	15	28.8
2	4,195	5/4.5	17	32.7
3	4,630	5/4.5	20	38.5
Total			52	100%

Parking for the project will include minimum of three (3) garage spaces (four spaces provided for Plan 3 units) and 27 on-street guest parking spaces. Total parking spaces provided is 203 spaces, which exceeds the minimum space requirement (117 spaces) per the County's parking ordinance.

Proposed open space and landscaping will consist of homeowner open space areas located within each private residential lot as well as private common areas located in dedicated community open space areas (three total), parkway landscaping and perimeter areas. Total landscaping is anticipated to consist of approximately 45% of the project site.

Paved and other impervious areas of the site include the project's project streets, curb, walkways and gutter improvements and residential building footprint of each residential lot. Total impervious surface is anticipated to consist of 55% of the project site.

Activities typical of residential developments can be anticipated for the residential portion of the project. These are anticipated to include day to day activities such as recreation, commuting and other typical residential activities.

E. Geotechnical Conditions

Topography – The topography of the project site is characterized as relatively flat, with the southwest corner of the site with the highest elevation of 530 feet above mean sea level (AMSL) and the lowest elevation at the northeastern corner of the site at approximately 482 feet above mean sea level (AMSL), the site slopes from west to east.

Soil Type and Geology – Geographically, the project site lies within the southeastern portion of the San Gabriel Valley, within the Peninsular Ranges Geomorphic Province. It is located in a broad alluvial valley that is several miles north of the northwest-trending Whittier Hills that are bounded by the Whittier Hills Fault. The southwest-trending San Jose Hills, located to the northeast of the site, are bound by Walnut Creek Fault. The site is located on a laterally extensive young alluvial fan deposit interpreted to be approximately middle Holocene age. It is about a quarter-mile from the channelized San Jose Creek, a west-flowing drainage that joins the San Gabriel

River several miles downstream. Based on field explorations indicate the site soils consist of design cut excavated into pre-existing native soils, and design fill placed over previously existing topography. Soils primarily consist of layers of fine-grained clay, sandy clay and sandy silt, with varying amounts of sand and gravel.

Groundwater – Groundwater was not encountered at a depth of approximately 50 feet below existing grade during field explorations. Historic high groundwater is estimated to be about 25 feet below existing grade.

Other Geotechnical Issues – Infiltration testing was conducted onsite in accordance with the County of Los Angeles testing guidelines and the measured infiltration rates ranged from 0.1 to 0.3 inches per hour, which does not include a factor of safety. Based on these infiltration tests, the site is not feasible for infiltration BMP's.

F. Watershed Area and Drainage Conditions

Watershed – The project site lies within the San Gabriel River Watershed. The watershed is completely urbanized, characterized by industrial, commercial and residential land uses, impervious surfaces, underground storm drains and engineered concrete-lined channels; it encompasses an area of approximately 640 square miles, including 19 cities that the San Gabriel river passes through. The channel flows pass through different sections in the San Gabriel river, diverting from the riverbed into four different spreading grounds, held behind several rubber dams for controlled flow and ground water recharge, and controlled through 10 miles of concrete channel bottom below Whittier Narrows Dam to past Coyote Creek.

Existing Drainage – Stormwater and surface water onsite generally flow from the south and southwest to the north and northeast. The onsite storm runoff discharges into Regalado Street and continues as gutter flow easterly to Angel Crest Drive and then northerly approximately 0.10 miles prior to discharging to an existing inlet. There is no existing storm drain system adjacent to the project.

All runoff is then conveyed to San Jose Creek, north of the project site. Storm flows will continue westerly and confluence with San Gabriel River and ultimately discharge to the Pacific Ocean.

Proposed Drainage – In the developed condition, stormwater and surface water onsite will be conveyed as in the existing condition, discharging onto Regalado Street. The southern portion of the site will discharge onto La Subida Drive and conveyed easterly to Angel Crest Drive. All runoff is conveyed to the existing inlet near the intersection of Angel Crest Drive and Tetley Street.

To address project requirements for LID BMPs, onsite water quality and low flows will be conveyed via a system of low flow inlets and low flow drainage pipes, to a Filterra Biofiltration BMP located in the project's northeastern open space area. Based on the available footprint, this biofiltration system is proposed as the BMP for the project site.

G. Other Site Considerations

Existing Utilities – Based on preliminary site assessment, the locations of existing utilities onsite and offsite would not pose any issues to the project's proposed BMPs.

H. Receiving Water Impairments

When designated beneficial uses of a particular water body are compromised by water quality, Section 303(d) of the Clean Water Act requires identifying and listing that water body as "impaired". Once a water body has been deemed impaired, a Total Maximum Daily Load ("TMDL") must be developed for each water quality constituent that compromises a beneficial use. A TMDL is an estimate of the total load of pollutants, from point, non-point, and natural sources, that a water body may receive without exceeding applicable water quality standards (with a "factor of safety" included). For point sources, including stormwater, the load allocation is referred to as a "Waste Load Allocation" (WLA) whereas for nonpoint sources, the allocation is referred to simply as a "Load Allocation".

Impairments to the project's receiving waters are as follows:

Receiving Water	303(d)	TMDL
San Jose Creek Reach 2 (Temple St. to I-10 at White Avenue)	Coliform Bacteria	None
San Jose Creek Reach 1 (SG Confluence to Temple St.)	Ammonia, pH, Total Dissolved Solids, Toxicity	None
San Gabriel River Reach 3 (Whittier Narrows to Ramona)	Indicator Bacteria	Metals
San Gabriel River Reach 2 (Firestone to Whittier Narrows Dam)	Coliform Bacteria, Cyanide, Lead	Metals
San Gabriel River Reach 1 (Estuary to Firestone)	Coliform Bacteria, pH	Metals
San Pedro Bay Near/Off Shore Zones	Chlordane, DDT (tissue & sediment), PCBs (Polychlorinated biphenyls), Sediment Toxicity	None

I. Pollutants of Concern

Urban storm water run-off in both the dry and rainy season contains pollutants that can be carried through the storm drain networks to lakes, streams and beaches. The anticipated pollutants of concern for this Project are as follows:

Bacteria and Viruses. Potential sources of bacteria for the Project include landscaping areas, pet wastes, food wastes and naturally occurring sources.

Nutrients. Potential sources of nutrients in storm water consist of the macro-nutrients nitrogen and phosphorous, which are typically found in fertilizers from landscaping areas, decaying vegetation from preservation/natural areas and trash and debris.

Pesticides. Potential sources of pesticides include common landscaping areas and homeowner-owned landscaping areas.

Sediment/Suspended Solids. Potential sources of sediment and suspended solids include landscaping areas.

Trash & Debris. Potential sources include misplacement or overfill of food wastes, wrappers, and other trash materials.

Metals. Potential sources include vehicles and vehicular fluids.

Oil and Grease. Potential sources of oil and grease include automotive vehicles and fluids and maintenance equipment.

Toxic Organic Compounds. Potential sources include pesticides, solvents and hydrocarbons.

II. BEST MANAGEMENT PRACTICES (BMP's)

BMPs are natural or constructed devices, procedures, rules or methods which, when implemented and followed, should reduce and/or eliminate the specific source of pollution of which the BMP is targeted.

A. Site Design Principles

The intention of site design principles is to reduce runoff peak flows and volumes resulting from land development. As required by the MS4 Permit and the County of Los Angeles Low Impact Development Manual, the following site design principles must be considered for use on all projects:

Site Planning – Project proponents must implement a holistic approach to site design in order to develop a more hydraulically-functional site, help maximize the effectiveness of on-site retention and integrate storm water management throughout the project site.

Protect and Restore Natural Areas — Conservation of natural areas, soils and vegetation helps to retain numerous functions of pre-development hydrology, including rainfall interception, infiltration, and evapotranspiration. Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Sensitive areas, such as streams and their buffers, floodplains, wetlands, steep slopes, and highly-permeable soils, should be protected and/or restored. Slopes can be a major source of sediment and should be properly protected and stabilized. Locating development in less sensitive areas of a project site and conserving naturally vegetated areas can minimize environmental impacts from storm water runoff.

The Project site was previously used as a school site. The conservation of natural areas is not applicable to the project. The project will incorporate the use of tree plantings throughout the project site, providing canopy interception of rain, thereby reducing runoff from developed site.

Minimize Land Disturbance – The purpose of this site design principle is to protect water quality by preserving the natural hydrologic function of the project site to the maximum extent practicable. By designing a project site layout to preserve natural hydrology and drainage ways at the project site, it reduces the need for grading and disturbance of native vegetation and soils. Siting buildings and impervious surfaces away from steep slopes, drainage ways, and floodplains limits the amount of grading and clearing necessary and reduces the hydrologic impact. This site design principle is most applicable in Greenfield settings, but opportunities to implement this principle may exist in redevelopment projects.

The project site proposes to maintain the pre-project hydrologic function of the site via the use of the project's proposed LID BMPs. Project land disturbance will be limited to the proposed redevelopment and take advantage of the existing site's pervious soils to address project runoff.

Minimize Impervious Area – The potential for discharge of pollutants in storm water runoff from a project site increases as the percentage of impervious area within the project site increases because impervious areas increase the volume and rate of storm

water runoff. Pollutants deposited on impervious areas are easily mobilized and transported by storm water runoff. Minimizing impervious area through site design is an important method to reducing the pollutant load in storm water runoff.

The Project proposes to minimize impervious area via the use of minimum-width roadway and sidewalk sections wherever feasible.

B. Source Control Measures

Source control measures are designed to prevent pollutants from contacting storm water runoff or preventing discharge of contaminated storm water runoff to the storm drain system and/or receiving water.

This section describes structural-type, source control measures that must be considered for implementation, in conjunction with appropriate non-structural source control measures, such as good housekeeping and employee training, to optimize pollution prevention.

Structural Controls

Storm Drain Message and Signage (S-1) – Storm drain stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets. The stencil contains a brief statement that prohibits the dumping of improper materials into the storm water conveyance system. Graphical icons, either illustrating antidumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message.

- All storm drain inlets and catch basins within the project area must be stenciled with prohibitive language (such as: "NO DUMPING – DRAINS TO OCEAN") and/or graphical icons to discourage illegal dumping.
- Signs and prohibitive language and/or graphical icons, which prohibit illegal dumping, must be posted at public access points along channels and creeks within the project area.
- Legibility of stencils and signs must be maintained.

All onsite catch basin will be stenciled with the language, "NO DUMPING – DRAINS TO OCEAN" or equivalent phrase. The stencils shall be maintained by the HOA.

Outdoor Material Storage Areas (S-2) - None proposed.

Outdoor Trash Storage/Waste Handling Areas (S-3) - None proposed.

Outdoor Loading/Unloading Dock Area (S-4) – None proposed.

Outdoor Vehicle/Equipment Repair/Maintenance Area (S-5) – None proposed. Work to be conducted indoors.

Outdoor Vehicle/Equipment/Accessory Wash Area (S-6) - None proposed.

Fuel and Maintenance Area (S-7) – None proposed.

Landscape Irrigation Practices (S-8) – Irrigation runoff provides a pathway for pollutants (i.e., nutrients, bacteria, organics, sediment) to enter the storm drain system. By controlling irrigation, runoff and the potential for pollutant transport is minimized.

Landscape and irrigation areas shall meet the following requirements:

- Minimize use of fertilizer, pesticides, and herbicides.
- Plan sites with sufficient landscaped area and dispersal capacity.
- Consult a landscape professional regarding appropriate plants, fertilizer, mulching applications and irrigation requirements to ensure healthy flora.
- Choose plants that minimize need for fertilizer and pesticides.
- Use native and/or drought tolerant plant species. Group plantings with similar water requirements.
- Employ use of mulch.
- Install rain sensors and pressure sensors to shut off irrigation system during, after rain storms and pressure drops/leaks.
- Implement integrated Pest Management Practices.

Building Materials Selection (S-9) – Building materials can potentially contribute pollutants of concern to storm water runoff through leaching. The use of alternative building materials can reduce pollutants in storm water by eliminating compounds that can leach into storm water runoff.

Alternative materials include the following:

- Replace use of pressure treated wood with cement-fiber or vinyl.
- Minimize the use of copper and galvanized metals on buildings and fencing.

Animal Care and Handling Facilities (S-10) - None proposed.

Outdoor Horticulture Areas (S-11) - None proposed.

Non-Structural Controls

Education of Property Owners, Tenants and Occupants – Educational materials will be provided to homeowners at close of escrow by the owner and periodically thereafter by the HOA to inform them of their potential impacts to downstream water quality. Materials include those described in Attachment F of this report.

Activity Restrictions – Activity restrictions to minimize potential impacts to water quality and with the purpose of protecting water quality will be prescribed by the project's Covenant, Conditions and Restrictions (CC&Rs).

Common Area Landscape Management – Maintenance activities for landscape areas shall be consistent with County and manufacturer guidelines for fertilizer and pesticide. Maintenance includes trimming, weeding and debris removal and vegetation planting and replacement. Stockpiled materials during maintenance activities shall be placed away from drain inlets and runoff conveyance devices. Wastes shall be properly disposed of or recycled. Application of materials shall be

limited to the minimum required amounts and restricted within 48 hours prior to rain events.

Common Area Litter Control – Litter control onsite will include the use of HOA, violation reporting and clean up during landscaping maintenance activities and as needed to ensure good housekeeping of the project's common areas.

Street Sweeping Private Streets— The project's private streets shall be swept on a quarterly (at minimum) basis, including prior to the start of the traditional rainy season and as needed.

C. Storm Water Quality Design Volume (SWQDv)

The design storm, from which the SWQDv is calculated, is defined as the greater of:

- The 0.75-inch, 24-hour rain event; or
- The 85th percentile, 24-hour rain event as determined from the Los Angeles County 85th percentile precipitation isoheytal map.

The SWQDv value for the project was determined using the HydroCalc Program.

The Q_{BMP} (cfs) was sized per the Adjusted Design Intensity to provide additional capture in lieu of volume reduction per Design Table 3 of the "Filterra Equivalency Analysis and Design Criteria" (August 2015) pursuant to Los Angeles County MS4 Permit, Order R4-2012-0175. Refer to BMP calculations in Attachment C.

Drainage Management Area	Acres	SQDv (cu-ft)	Q _{BMP} (cfs)	Filterra Size ⁽⁷⁾
DMA 1	3.10	6,629.1	0.62	Filterra Bioscape – 8'x24'
DMA 2	1.28	2,373.2	0.26	Filterra – 13'x7'
DMA 3	6.14	13,130.2	1.23	Filterra Bioscape – 12'x32'
DMA 4	2.15	4,597.6	0.43	Filterra – 8'x18'

(1) County approved "Filterra" brand device or County approved proprietary equivalent.

D. Storm Water Quality Control Measures

Storm water quality control measures function to augment site design principles and source control measures to reduce storm water runoff volume and potential pollutant loads in runoff to the maximum extent practicable.

Based on the project site's infiltration test results, measured infiltration rates for the site ranged from 0.1 to 0.3 inches per hour, per Preliminary Geotechnical Evaluation and Design Recommendations for Proposed Residential Development, Former La Subida Elementary School Site, Hacienda Heights, California report dated March 13, 2018. Infiltration BMP's were considered but due to poor infiltration, Infiltration BMPs are not feasible for the proposed development.

Harvest and Reuse (aka. Rainwater Harvesting) BMPs are LID BMPs that capture and store storm water runoff for later use. These BMPs are engineered to store a specified volume of water and have no design surface discharge until this volume is exceeded. Harvest and use BMPs include both above-ground and below-ground cisterns.

Examples of uses for harvested water include irrigation, toilet and urinal flushing, vehicle washing, evaporative cooling, industrial processes and other non-potable uses. Harvest and use is not feasible due to limited common area landscaping and the use of xeriscape landscaping that require low water use.

Selection of the project's treatment BMPs was primarily based on MS4 Permit requirements, which requires that all designated projects retain the SWQDv on-site using retention based measures, unless retention based measures are determined to be infeasible. The project will propose four (4) Filterra units at DMAs 1 through 4 (T-6 Proprietary Treatment Control Measures) to address treatment of the project's runoff. Per the RWQCB approval letter dated October 9, 2017, Condition 1, the Filterra units were sized based on the Adjusted Design Intensity to provide additional capture in lieu of volume reduction per Design Table 3 of "Filterra Equivalency Analysis and Design Criteria" pursuant to Los Angeles County MS4 Permit, Order R4-2012-0175.

Consideration was also given to effectiveness in addressing the project's anticipated pollutants of concern; as well as compliance with receiving water impairments and discharge limitations (TMDL for Metal).

To meet the requirements of the metals TMDL, all low flow runoff onsite will be conveyed to the project's BMP, Filterra Biofiltration System.

To meet the zero trash discharge requirement, all project catch basins will be equipped with catch basin inserts/inlet screens to remove trash/litter, debris and sediment from runoff entering the project's storm drain system.

E. Hydromodification Requirements

The project is exempt from the hydromodification requirements of the MS4 Permit, as the project discharges through a fully improved storm drain system that discharges to a receiving water San Jose Creek and the San Gabriel River that is not susceptible to hydromodification impacts.

III. Storm Water Quality Control Measure Maintenance

- 1. Maintenance and inspection activities for the identified BMPs will be performed as indicated on the enclosed BMP Inspection and Maintenance Responsibility/Frequency Matrix in Attachment D.
- 2. The project owners and proponents, LENNAR shall employ self-inspections and record keeping for BMPs, as applicable. The owner shall retain all maintenance records for a period of five (5) years after the recorded inspection date for the lifetime of the Project. The records shall be made readily available for review by all government agencies. Depending on the type of BMP, minimum frequency of inspections may range from weekly, to once a month, quarterly, or yearly.
- 3. The contact information for the owner is as follows:

Property
Owner: LENNAR

Contact: Andrew Han

15131 Alton Parkway, Suite

Address: 365, Irvine, CA 92618

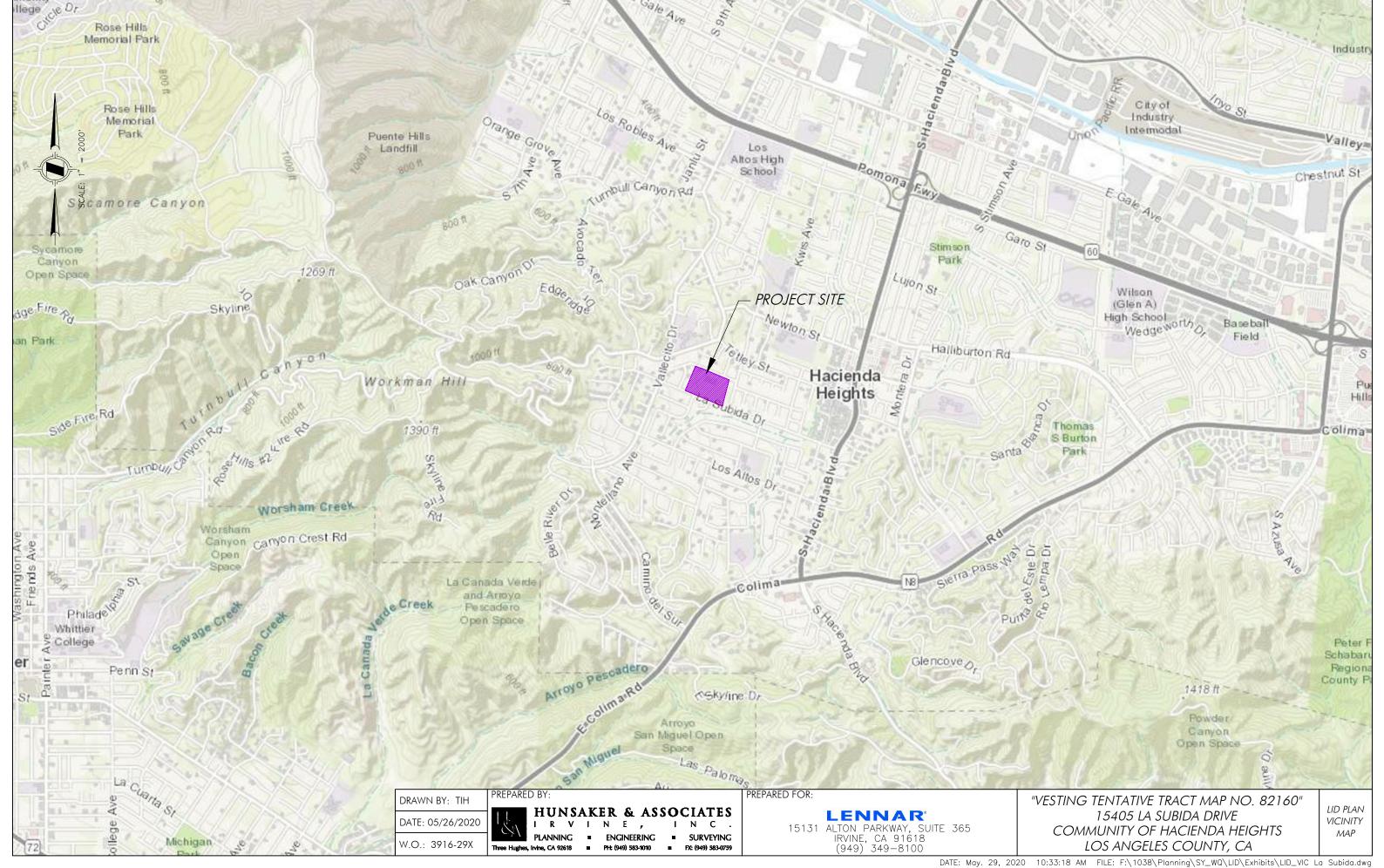
Phone: (949) 349-8234

LENNAR shall be responsible for the management of the residential portion of the project site and implementation and maintenance of the requirements of this LID Report until such time, the property has not been turned over to the HOA for ownership and maintenance.

- 4. A copy of the project's on-site BMP maintenance covenant to be recorded at the County of Los Angeles shall be inserted in Attachment D. This maintenance covenant has been devised by the County of Los Angeles to legally assign responsibilities for maintenance of proposed BMP facilities such that they run with the land. In order to comply with item A of the LID Report (provide proof of ongoing BMP maintenance), responsibilities have been listed as an encumbrance on the property (per the maintenance covenant), and shall be signed by the owners, and shall be recorded in the Los Angeles County Recorder's Office.
- 5. Should a transfer of ownership occur, appropriate notification shall be filed with the County of Los Angeles confirming the change in responsibility and continued implementation of stormwater management requirements.

ATTACHMENTS

ATTACHMENT A VICINITY MAP



ATTACHMENT B SITE PLAN



ATTACHMENT C BMP CALCULATIONS AND DETAILS

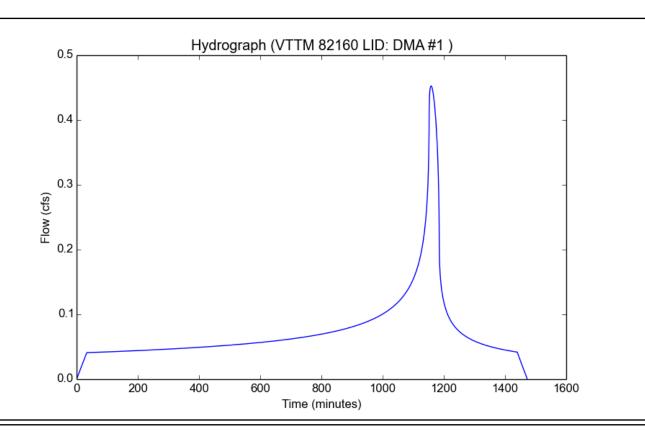
BMP Calculations

 $\label{location:file_locatio$

Input I	Paramete	ers
---------	----------	-----

Project Name	VTTM 82160 LID
Subarea ID	DMA #1
Area (ac)	3.1
Flow Path Length (ft)	640.0
Flow Path Slope (vft/hft)	0.017
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Jaipat Modalio	
Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2703
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	33.0
Clear Peak Flow Rate (cfs)	0.4525
Burned Peak Flow Rate (cfs)	0.4525
24-Hr Clear Runoff Volume (ac-ft)	0.1522
24-Hr Clear Runoff Volume (cu-ft)	6629.1323
,	

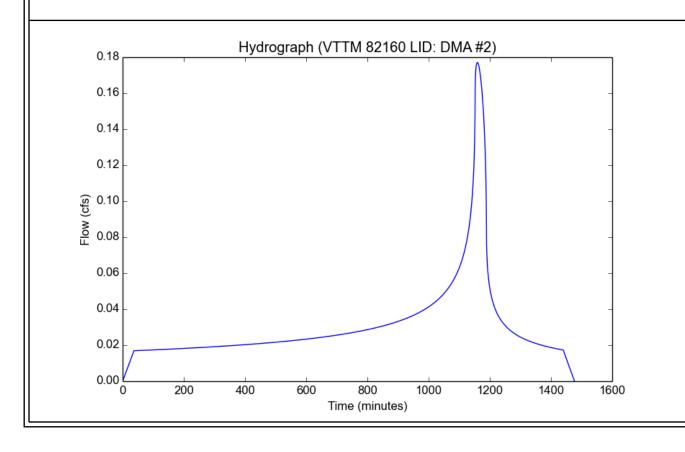


 $\label{location:file_locatio$

Input I	Paramete	ers
---------	----------	-----

Project Name	VTTM 82160 LID
Subarea ID	DMA #2
Area (ac)	1.28
Flow Path Length (ft)	870.0
Flow Path Slope (vft/hft)	0.029
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Carpat Rocalio	
Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2562
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	37.0
Clear Peak Flow Rate (cfs)	0.1771
Burned Peak Flow Rate (cfs)	0.1771
24-Hr Clear Runoff Volume (ac-ft)	0.0628
24-Hr Clear Runoff Volume (cu-ft)	2737.2

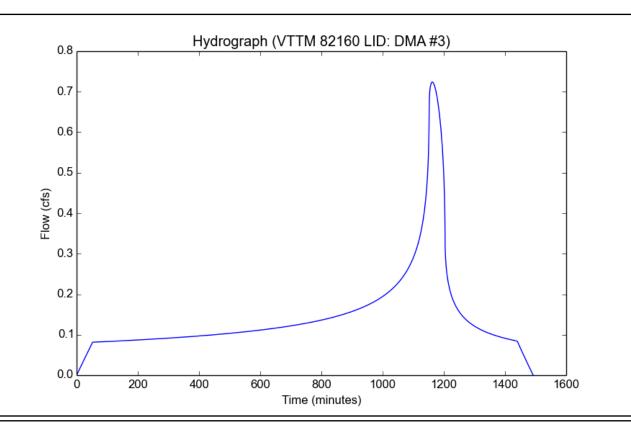


 $\label{location:file_locatio$

Input	Param	eters
-------	--------------	-------

Project Name	VTTM 82160 LID
Subarea ID	DMA #3
Area (ac)	6.14
Flow Path Length (ft)	1325.0
Flow Path Slope (vft/hft)	0.019
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2183
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	52.0
Clear Peak Flow Rate (cfs)	0.7239
Burned Peak Flow Rate (cfs)	0.7239
24-Hr Clear Runoff Volume (ac-ft)	0.3014
24-Hr Clear Runoff Volume (cu-ft)	13130.2355

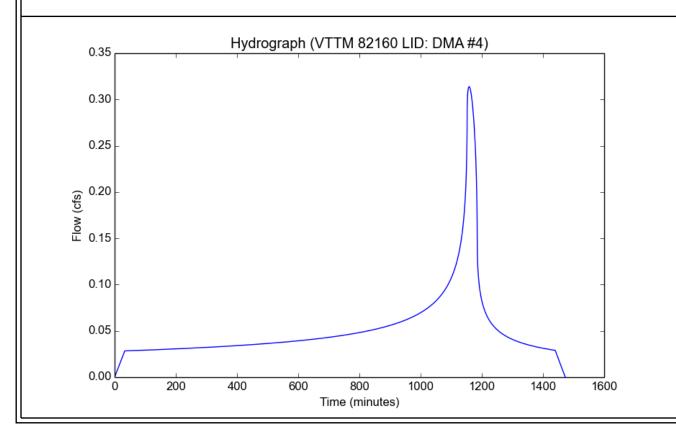


 $\label{location:file_locatio$

Input Parameters

Project Name	VTTM 82160 LID
Subarea ID	DMA #4
Area (ac)	2.15
Flow Path Length (ft)	760.0
Flow Path Slope (vft/hft)	0.034
85th Percentile Rainfall Depth (in)	1.1
Percent Impervious	0.55
Soil Type	16
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Modeled (85th percentile storm) Rainfall Depth (in)	1.1
Peak Intensity (in/hr)	0.2703
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.54
Time of Concentration (min)	33.0
Clear Peak Flow Rate (cfs)	0.3139
Burned Peak Flow Rate (cfs)	0.3139
24-Hr Clear Runoff Volume (ac-ft)	0.1055
24-Hr Clear Runoff Volume (cu-ft)	4597.624



BMP Details





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

	1 1101101 5-15		
Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #1- Filterra #1
Drainage Area Inputs			
Drainage Area		135036	l ft⁴
Runoff coefficient		0.54	<u>-</u>
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in
LA County Rainfall Depth Analysis	,		
Filterra Configuration (Select from D	Prop-Down)	Offline	
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.	
<u>Constants</u>			
LAX Airport 85th Percentile, 24-hour de	oth (for reference only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft²
Outputs			
Stormwater Quality Design Volume		6,684	ft ³
Design Rainfall Intensity for Equivalent L	ong Term Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		0.58	cfs
Design Alternatives Available		Filterra + Storage Only	
Design Recommendations			
Primary Recommendation - Stand Ald	one Filterra		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		0.62	cfs
Required Filterra Area		192	ft²
Filterra Model ID		FTBSV 8X24	
Alternative Recommendation - Filtern	ra + Infiltration Storage		
Required Filterra Area		181	ft ²
Filterra Model ID		FTBSV 8X23	_
ChamberMaxx volume		0	ft³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name Hunsak	er & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #2- Filterra #2
Drainage Area Inputs			
Drainage Area		55756	1 ft²
Runoff coefficient		0.54	1 .
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyperlink belo	w)	1.10	in
LA County Rainfall Depth Analysis	•		•
Filterra Configuration (Select from Drop-Dow	<u>n)</u>	Offline	
Refer to "Filterra Configurations" tab for description	ons and detail drawings	for download.	=
<u>Constants</u>			_
LAX Airport 85th Percentile, 24-hour depth (for ref	erence only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft ²
<u>Outputs</u>			_
Stormwater Quality Design Volume		2,760	ft ³
Design Rainfall Intensity for Equivalent Long Term	Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		0.24	cfs
Design Alternatives Available		Filterra + Storage Only	_
Design Recommendations			
Primary Recommendation - Stand Alone Filteri	<u>ra</u>		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		0.26	cfs
Required Filterra Area		79	ft ²
Filterra Model ID		FT 7x13 / 13x7	
<u> Alternative Recommendation - Filterra + Infiltr</u>	ation Storage		
Required Filterra Area		75	ft ²
Filterra Model ID		FT 7x13 / 13x7	
ChamberMaxx volume		0	ft ³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

	1 1101101 5 15 1		
Contact Information		Project Information	
Engineer of Record Name	Gary Guan	Project Name	La Subida
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights
Engineer of Record Office Zip Code	92618	Catchment Name	DMA #3- Filterra #3
Drainage Area Inputs			
Drainage Area		267458	ft⁴
Runoff coefficient		0.54	-
Time of concentration		30	min
Long term reliable infiltration rate		0.00	in/hr
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in
LA County Rainfall Depth Analysis	·		
Filterra Configuration (Select from D	Prop-Down)	Offline	
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.	
<u>Constants</u>			
LAX Airport 85th Percentile, 24-hour de	oth (for reference only)	1.02	in
Filterra hydraulic loading capacity		1.45	gpm/ft ²
Outputs			
Stormwater Quality Design Volume		13,239	ft ³
Design Rainfall Intensity for Equivalent I	ong Term Capture	0.320	in/hr
Site Scaling Factor		1.08	-
Stormwater Quality Design Flow Rate		1.15	cfs
Design Alternatives Available		Filterra + Storage Only	
Design Recommendations			
Primary Recommendation - Stand Ale	one Filterra		
Adjusted Filterra Design Intensity		0.340	in/hr
Stormwater Quality Design Flow Rate		1.23	cfs
Required Filterra Area		379	ft²
Filterra Model ID		FTBSV 12X32	
Alternative Recommendation - Filter	ra + Infiltration Storage		
Required Filterra Area		357	ft ²
Filterra Model ID		FTBSV 12X31.5	
ChamberMaxx volume		0	ft ³
ChamberMaxx count		0	chambers

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.





<u>Applicable in the Area Goverened by the Los Angeles County MS4 Permit</u>
(NPDES PERMIT NO. CASO04001; ORDER NO. R4-2012-0175)

For final design please contact:

Alexandra Dubrock - Stormwater Consultant

adubrock@conteches.com

Phone: 949-217-4663

Contact Information		Project Information		
Engineer of Record Name	eer of Record Name Gary Guan		La Subida	
Engineer of Record Company Name	Hunsaker & Associates Irvine	Project Location	Hacienda Heights	
ngineer of Record Office Zip Code 92618		Catchment Name	DMA #4- Filterra #4	
Drainage Area Inputs		<u> </u>		
Drainage Area		93654	ft⁴	
Runoff coefficient		0.54	-	
Time of concentration		30	min	
Long term reliable infiltration rate		0.00	in/hr	
85th percentile, 24-hour depth (see hyp	erlink below)	1.10	in	
LA County Rainfall Depth Analysis				
Filterra Configuration (Select from D	Prop-Down)	Offline		
Refer to "Filterra Configurations" tab for	descriptions and detail drawings	for download.		
<u>Constants</u>				
LAX Airport 85th Percentile, 24-hour dep	oth (for reference only)	1.02	in	
Filterra hydraulic loading capacity		1.45	gpm/ft ²	
<u>Outputs</u>				
Stormwater Quality Design Volume		4,636	ft ³	
Design Rainfall Intensity for Equivalent L	ong Term Capture	0.320	in/hr	
Site Scaling Factor		1.08	-	
Stormwater Quality Design Flow Rate		0.40	cfs	
Design Alternatives Available		Filterra + Storage Only		
Design Recommendations				
Primary Recommendation - Stand Ald	one Filterra			
Adjusted Filterra Design Intensity		0.340	in/hr	
Stormwater Quality Design Flow Rate		0.43	cfs	
Required Filterra Area		133	ft²	
Filterra Model ID		FT 18x8		
Alternative Recommendation - Filtern	a + Infiltration Storage			
Required Filterra Area		125	ft ²	
Filterra Model ID		FT 16x8		
ChamberMaxx volume		0	ft ³	
ChamberMaxx count		0	chambers	

^{1.} Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report prepared by Geosyntec Consultants, entitled "Filterra Equivalency Analysis and Design Criteria" which is the basis for this design tool.

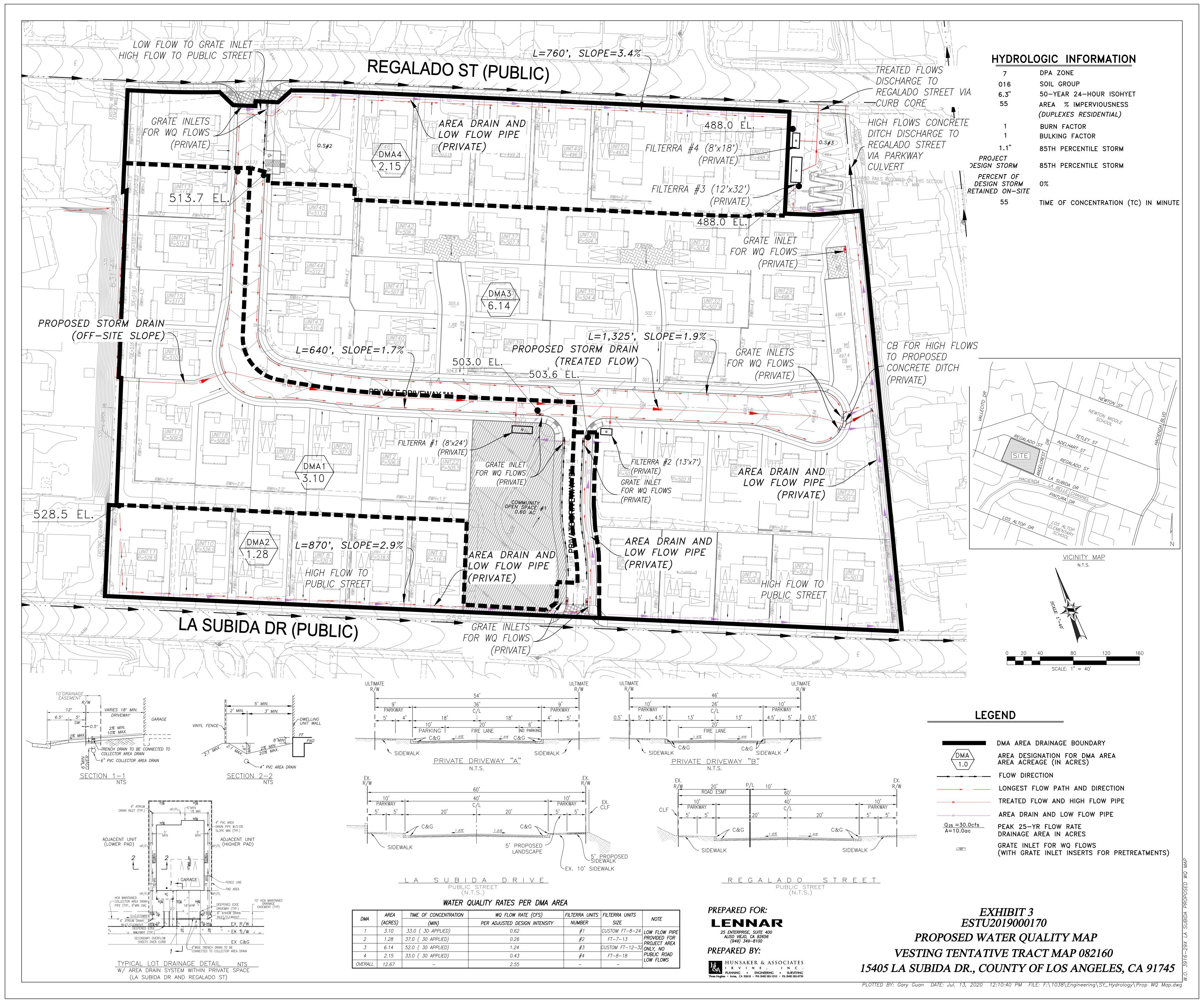
^{2.} Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.

^{3.} Filterra is only applicable as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

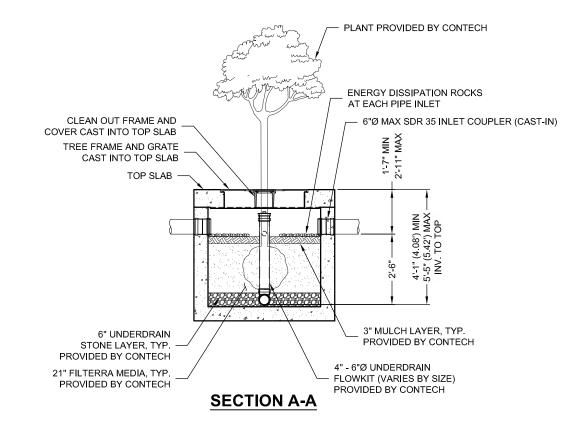
^{4.} Hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit must be considered separately regardless of what type of biofiltration is used.

^{5.} Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by Contech Engineered Solutions.

^{6.} In the area governed by the Los Angeles Region Phase I stormwater permit, conventional biofilters must be sized to treat 1.5X the SWQDV. This results in an average annual capture rate of 93%. Filterra systems sized using this tool will also treat at least 93% of the average annual runoff volume.



PLAN VIEW





FT-P STANDARD OFFLINE CONFIGURATION								
DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (L x W)	OUTLET PIPE	TREE GRATE QTY & SIZE	MIN NO. OF INLET PIPES		
FT0404-P	ALL	4 x 4	4 x 4	4" SDR 35	(1) 3' x 3'	1		
FT0604-P	N/A CA	6 x 4	6 x 4	4" SDR 35	(1) 3' x 3'	1		
FT0606-P	ALL	6 x 6	6 x 6	4" SDR 35	(1) 3' x 3'	1		
FT06504-P	CA ONLY	6.5 x 4	6.5 x 4	4" SDR 35	(1) 3' x 3'	1		
FT078045-P	MID-ATL ONLY	7.83 x 4.5	7.83 x 4.5	4" SDR 35	(1) 3' x 3'	1		
FT0804-P	N/A MID-ATL	8 x 4	8 x 4	4" SDR 35	(1) 3' x 3'	1		
FT0806-P	ALL	8 x 6	8 x 6	4" SDR 35	(1) 4' x 4'	1		
FT1006-P	ALL	10 x 6	10 x 6	6" SDR 35	(1) 4' x 4'	2		
FT1206-P	ALL	12 x 6	12 x 6	6" SDR 35	(2) 4' x 4'	2		
FT1307-P	ALL	13 x 7	13 x 7	6" SDR 35	(2) 4' x 4'	2		
FT1408-P	CALL CONTECH	14 x 8	14 x 8	6" SDR 35	(2) 4' x 4'	3		
FT1608-P	CALL CONTECH	16 x 8	16 x 8	6" SDR 35	(2) 4' x 4'	3		
FT1808-P	CALL CONTECH	18 x 8	18 x 8	6" SDR 35	(2) 4' x 4'	3		
FT2008-P	CALL CONTECH	20 x 8	20 x 8	6" SDR 35	(3) 4' x 4'	4		
FT2208-P	CALL CONTECH	22 x 8	22 x 8	6" SDR 35	(3) 4' x 4'	4		

N/A = NOT AVAILABLE

The design and information shown on this drawing is provided as a service to the project owner, engineer and contractor by Contech Engineered Solutions LLC or one of its affiliated companies ("Contech"). Neither this drawing, nor any part thereof, may be used, reproduced or modified in any manne without the prior written consent of Contech. Failure to comply is done at the user's own risk and Contech expressly disclaims any liability representable. The prior written consent of Contech supplied information upon which the drawing is based and actual field conditions are encountered as sits work progresses, here discrepancies between the supplied information upon which the drawing is based and actual field conditions are encountered as sits work progresses, these discrepancies must be reported to Contech immediately for re-eviduation of the design. Contech accepts no liability for designs based on missing, incompleted to miscardier information supplied by others, supplied by others supplied to when supplied to whe

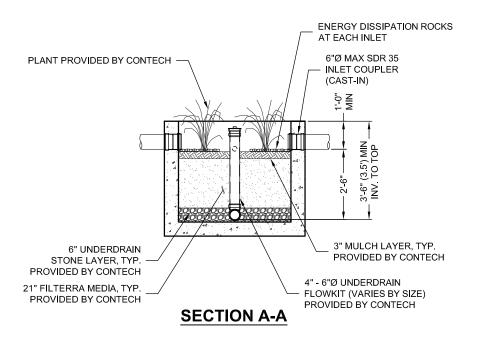


9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069

800-338-1122 513-645-7000 513-645-7993 FAX

FILTERRA OFFLINE - PIPE (FT-P)
CONFIGURATION DETAIL

PLAN VIEW



FTBSV-P CONFIGURATION					
DESIGNATION	AVAILABILITY	MEDIA BAY SIZE	VAULT SIZE (L x W)	OUTLET PIPE	MIN NO. OF INLET PIPES
FTBSV0404-P	ALL	4 x 4	4 x 4	4" SDR 35	1
FTBSV0604-P	N/A CA	6 x 4	6 x 4	4" SDR 35	1
FTBSV0606-P	ALL	6 x 6	6 x 6	4" SDR 35	1
FTBSV06504-P	CA ONLY	6.5 x 4	6.5 x 4	4" SDR 35	1
FTBSV078045-P	MID-ATL ONLY	7.83 x 4.5	7.83 x 4.5	4" SDR 35	1
FTBSV0804-P	N/A MID-ATL	8 x 4	8 x 4	4" SDR 35	1
FTBSV0806-P	ALL	8 x 6	8 x 6	4" SDR 35	1
FTBSV1006-P	ALL	10 x 6	10 x 6	6" SDR 35	2
FTBSV1206-P	ALL	12 x 6	12 x 6	6" SDR 35	2
FTBSV1307-P	ALL	13 x 7	13 x 7	6" SDR 35	2
FTBSV1408-P	CALL CONTECH	14 x 8	14 x 8	6" SDR 35	3
FTBSV1608-P	CALL CONTECH	16 x 8	16 x 8	6" SDR 35	3
FTBSV1808-P	CALL CONTECH	18 x 8	18 x 8	6" SDR 35	3
FTBSV2008-P	CALL CONTECH	20 x 8	20 x 8	6" SDR 35	4
FTBSV2208-P	CALL CONTECH	22 x 8	22 x 8	6" SDR 35	4

N/A = NOT AVAILABLE



The design and information shown on this drawing is provided as a service to the project owner, engineer and contractor by Contech Engineered Solutions LLC or one of its affiliated companies ("Contech"). Neither this drawing, nor any part thereof, may be used, reproduced or modified in any man without the prior written consent of Contech. Failure to comply is done at the user's own risk and Contech expressly disclaims any liability or responsibility for such use. If discrepancies between the supplied information upon which the drawing is based and actual field conditions are encountered as work progresses, these discrepandes must be reported to Contech immediately for re-evaluation of the design. Contech accepts no liability for designs based on missing, promplete or in inaccurate information supplied by others on supplied by others.



 www.ContechES.com

 9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069

 800-338-1122
 513-645-7000
 513-645-7993 FAX

FILTERRA BIOSCAPE VAULT OFFLINE WITH PIPE INLET (FTBSV-P) CONFIGURATION DETAIL





The experts you need to



Contech is the leader in stormwater solutions, helping engineers, contractors and owners with infrastructure and land development projects throughout North America.

With our responsive team of stormwater experts, local regulatory expertise and flexible solutions, Contech is the trusted partner you can count on for stormwater management solutions.

Your Contech Team



STORMWATER CONSULTANT

It's my job to recommend the best solution to meet permitting requirements.



STORMWATER DESIGN ENGINEER

I work with consultants to design the best approved solution to meet your project's needs.



REGULATORY MANAGER

I understand the local stormwater regulations and what solutions will be approved.



SALES ENGINEER

I make sure our solutions meet the needs of the contractor during construction.



Low Impact Development in a Small Footprint – Filterra®

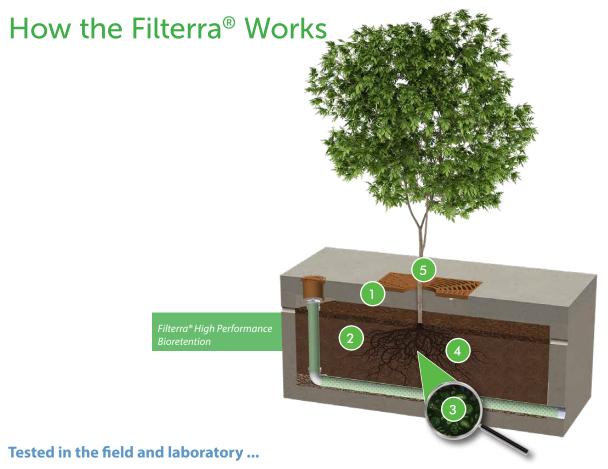
Filterra is an engineered high-performance bioretention system. While it operates similar to traditional bioretention, its high flow media allows for a reduction in footprint of up to 95% versus traditional bioretention practices. Filterra provides a Low Impact Development (LID) solution for tight, highly developed sites such as urban development projects, commercial parking lots, residential streets, and streetscapes. Its small footprint also reduces installation and life cycle costs versus traditional bioretention. Filterra can be configured in many different ways to enhance site aesthetics, integrate with other LID practices, or increase runoff reduction through infiltration below or downstream of the system.

At the Manchester Stormwater
Park seen above, the Filterra
systems surrounding the central
courtyard allowed for the creation
of a community space with parking,
sidewalks, and benches in a quaint
downtown area. A traditional
bioretention system treating the
same drainage area would have
occupied the entire park area leaving
no room for these amenities.



Ofilterra Bioscape.





- 1 Stormwater enters the Filterra through a pipe, curb inlet, or sheet flow and ponds over the pretreatment mulch layer, capturing heavy sediment and debris. Organics and microorganisms within the mulch trap and degrade metals and hydrocarbons. The mulch also provides water retention for the system's vegetation.
- 2 Stormwater flows through engineered Filterra media which filters fine pollutants and nutrients. Organic material in the media removes dissolved metals and acts as a food source for root-zone microorganisms. Treated water exits through an underdrain pipe or infiltrates (if designed accordingly).
- Rootzone microorganisms digest and transform pollutants into forms easily absorbed by plants.
- 4 Plant roots absorb stormwater and pollutants that were transformed by microorganisms, regenerating the media's pollutant removal capacity. The roots grow, provide a hospitable environment for the rootzone microorganisms and penetrate the media, maintaining hydraulic conductivity.
- 5 The plant trunk and foliage utilize nutrients such as Nitrogen and Phosphorus for plant health, sequester heavy metals into the biomass, and provide evapotranspiration of residual water within the system.



Plants and organic material are vital to the long term performance of bioretention systems

Filterra® Features and Benefits

FEATURE	BENEFITS
High biofiltration media flow rate (up to 140"/hr+)	Greatly reduced footprint versus traditional bioretention and LID solutions
Filterra system is packaged, including all components necessary for system performance	Quality control for easy, fast and successful installation
Quick and easy maintenance	Low lifecycle costs
Variety of configurations and aesthetic options	Integrates easily into any site or landscape plan
Natural stormwater management processes featuring organics and vegetation	Meets Low Impact Development requirements and ensures long-term performance



The Filterra system can be configured with many different aesthetic options

Select Filterra® Approvals

Filterra is approved through numerous local, state and federal verification programs, including:

- New Jersey Department of Environmental Protection (NJ DEP)
- Washington Department of Ecology (GULD) Basic, Enhanced, Phosphorus, and Oil
- Maryland Department of the Environment Environmental Site Design (ESD)
- Texas Commission on Environmental Quality (TCEQ)
- Virginia Department of Environmental Quality (VA DEQ)
- Maine Department of Environmental Protection (ME DEP)
- Atlanta, GA Regional Commission
- Los Angeles County, CA Alternate to Attachment H
- City of Portland, Oregon Bureau of Environmental Services
- North Carolina Department of Environmental Quality (NC DEQ)





Filterra® Performance Testing Results



APPLICATION TIPS

- The Filterra system has been tested under industry standard protocols and has proven its pollutant removal performance and system longevity.
- Contech invests significant resources in media blending calibration and product testing to ensure our media meets our strict performance specifications every time.
- Keep regulators and owners happy by selecting a product with predictable and proven maintenance longevity.



POLLUTANT OF CONCERN	MEDIAN REMOVAL EFFICIENCY	MEDIAN EFFLUENT CONCENTRATION (MG/L)
Total Suspended Solids (TSS)	86%	3.3
Total Phosphorus - TAPE (TP)	70%	0.05
Total Nitrogen (TN)	34%	0.54
Total Copper (TCu)	55%	0.004
Total Dissolved Copper	43%	0.003
Total Zinc (TZn)	56%	0.04
Total Dissolved Zinc	54%	0.1
Total Zinc (TZn)	56%	0.04
Total Petroleum Hydrocarbons	87%	0.71

Each batch of Filterra® media has been extensively tested to ensure consistent performance every time.

> UVA (TARP) Field Study - 2006 Herrera (TAPE) Study - 2009 Herrera (TAPE) Study - 2014 NC State Study - 2015

Sources:

Note: Some jurisdictions recognize higher removal rates. Contact your Contech Stormwater Consultant for performance expectations.

Filterra® Maintenance

Activation and first year of maintenance is included with every system.*

With proper routine maintenance, the engineered media within the Filterra system should last as long as traditional bioretention media. Routine maintenance is included by the manufacturer on all Filterra systems for the first year after activation.* This includes a maximum of 2 visits to remove debris, replace pretreatment mulch, and prune the vegetation.

Maintenance is low-cost, low-tech and simple:

- Remove trash, sediment, and mulch
- Replace with a fresh 3" layer of mulch
- No confined space entry or special tools
- Easily performed by landscape contractor or facilities maintenance provider



Filterra offers high performance bioretention for advanced pollutant removal with easy maintenance.



Plant health evaluation and pruning is important to encourage growth.

All stormwater treatment systems require maintenance for effective operation.

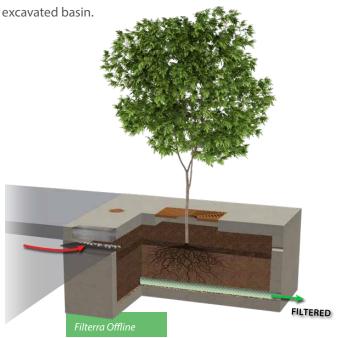


^{*} Some exclusions may apply.

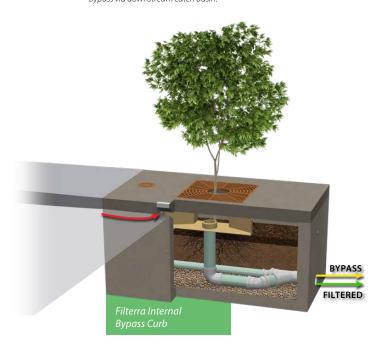
Filterra® Configurations

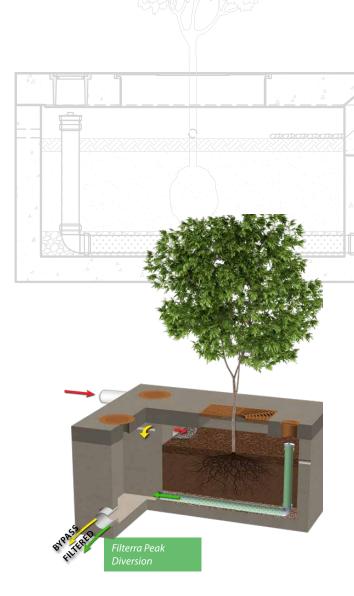
Multiple system configurations integrate with site hydraulic design and layout ...

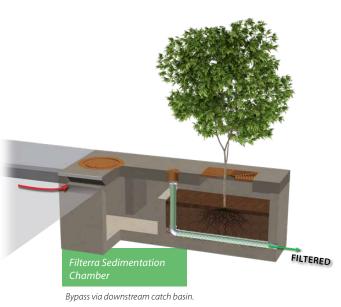
The Filterra is available in a variety of precast configurations as well as Filterra Bioscape, which can be installed directly into an



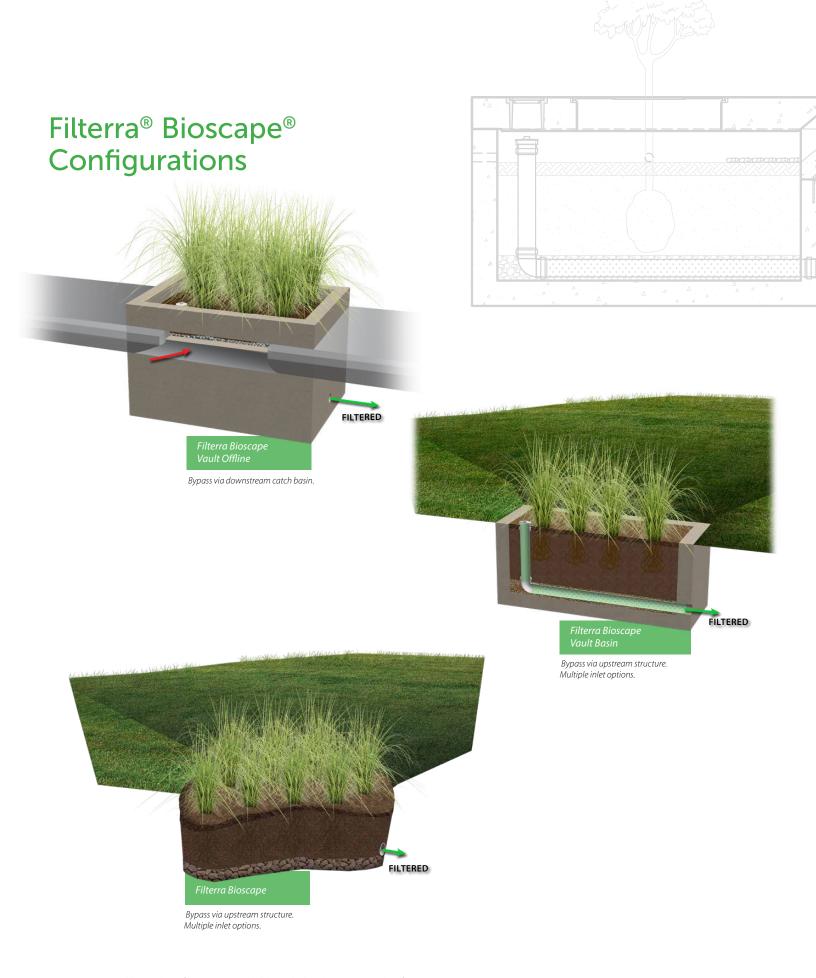
Bypass via downstream catch basin.







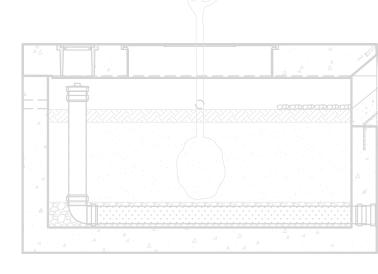
^{*}Additional configurations available, including offline - pipe, peak diversion - grate, and internal bypass curb-chamber.



*Additional configurations available, including bioscape vault offline pipe.

Filterra® Aesthetic Options

Multiple aesthetic options to enhance the appearance and integrate with landscaping ...









Custom/Decorative Tree Grate









Open Top Planter - Filterra Bioscape



Street Tre

Filterra® Bioscape®







Large-scale Filterra that can be customized to your site ...

- Ideal for Filterra systems greater than 300 square feet
- Design with or without containment structure
- Incorporate infiltration directly below the system, where required
- Combine with upstream storage or downstream infiltration
- Use as an alternative to larger regional traditional bioretention systems
- Easily add pretreatment Hydrodynamic Separator for large-scale or heavy pollutant loading applications



A partner









Few companies offer the wide range of highquality stormwater resources you can find with us — state-of-the-art products, decades of expertise, and all the maintenance support you need to operate your system cost-effectively.

THE CONTECH WAY

Contech® Engineered Solutions provides innovative, cost-effective site solutions to engineers, contractors, and developers on projects across North America. Our portfolio includes bridges, drainage, erosion control, retaining wall, sanitary sewer and stormwater management products.

TAKE THE NEXT STEP

For more information: www.ContechES.com

NOTHING IN THIS CATALOG SHOULD BE CONSTRUED AS A WARRANTY. APPLICATIONS SUGGESTED HEREIN ARE DESCRIBED ONLY TO HELP READERS MAKE THEIR OWN EVALUATIONS AND DECISIONS, AND ARE NEITHER GUARANTEES NOR WARRANTIES OF SUITABILITY FOR ANY APPLICATION. CONTECH MAKES NO WARRANTY WHATSOEVER, EXPRESS OR IMPLIED, RELATED TO THE APPLICATIONS, MATERIALS, COATINGS, OR PRODUCTS DISCUSSED HEREIN. ALL IMPLIED WARRANTIES OF MERCHANTABILITY AND ALL IMPLIED WARRANTIES OF FITNESS FOR ANY PARTICULAR PURPOSE ARE DISCLAIMED BY CONTECH. SEE CONTECH'S CONDITIONS OF SALE (AVAILABLE AT WWW.CONTECHES.COM/COS) FOR MORE INFORMATION.



Get social with us: **f** in **y**





800-338-1122 | www.ContechES.com

ATTACHMENT D OPERATION & MAINTENANCE PLAN

O&M Plan Structural BMP Inspection and Maintenance Responsibility/Frequency Matrix

BMP Maintenance Covenant

BMP Inspection and Maintenance Responsibility/Frequency Matrix				
ВМР	RESPONSIBILITY	INSPECTION/MAINTENANCE ACTIVITIES	MINIMUM FREQUENCY	
Structural BMPs				
Storm Drain Message and Signage (S-1)	НОА	Storm drain stencils shall be inspected for legibility, at minimum, once prior to the storm season, no later than October 1 st each year. Those determined to be illegible will be re-stenciled as soon as possible.	Annually	
Outdoor Material Storage Areas (S-2)	НОА	Ensure all materials with potential to contaminate runoff be placed in enclosures that prevent contact with runoff or spillage to storm water conveyance system.	Ongoing	
Outdoor Trash Storage/Waste Handling Areas (S-3)	НОА	Inspect trash enclosures to ensure proper disposal of trash and pick up of any trash/debris around dumpster has occurred. Inspect for leaks and clean up materials as soon as possible. Ensure lids are closed when not actively used.	Ongoing	
Outdoor Vehicle/Equipment/Accessory Wash Area (S-6)	НОА	Ensure minimal wash water is used and that wash water does not enter the storm drain system. Wash area should be in a sump condition and precluded from run-on. Wash water should be collected and disposed of in the sanitary sewer system.	Ongoing	
Fuel and Maintenance Area (S-7)	НОА	Inspect with use for spills, proper clean up of spills and materials. Ensure adequate supply of spill cleanup material and proper disposal of wastes.	Ongoing	

BMP In	BMP Inspection and Maintenance Responsibility/Frequency Matrix				
ВМР	RESPONSIBILITY	INSPECTION/MAINTENANCE ACTIVITIES	MINIMUM FREQUENCY		
Landscape Irrigation Practices (S-8)	НОА	In conjunction with routine maintenance activities, verify that landscape design continues to function properly by adjusting properly to eliminate overspray to hardscape areas, and to verify that irrigation timing and cycle lengths are adjusted in accordance with water demands, given time of year, weather, day or night time temperatures based on system specifications and local climate patterns.	Weekly		
Building Materials Selection (S-9)	НОА	In conjunction with routine maintenance activities, alternative building materials that pose minimal potential for pollutant leaching should be considered for use in maintenance and replacement projects for homeowners.	Ongoing		
Non-Structural BMPs					
Education of Property Owners, Tenants and Occupants	НОА	Educational materials will be provided to homeowners at close of escrow by the owner and thereafter on an annual basis by the HOA. Materials shall include those provided in Attachment A of this Plan and any updated materials.	Close of escrow and annually.		
Activity Restrictions	НОА	The Owner will prescribe activity restrictions to protect surface water quality, through a Covenant, Conditions and Restrictions (CC&Rs) agreement, or other equally effective measure, for the project. Upon takeover of site responsibilities by the HOA, the HOA shall be responsible for ensuring residents compliance. RHCC shall prescribe and implement activity restrictions required of its users and staff.	Ongoing		

BMP Inspection and Maintenance Responsibility/Frequency Matrix				
ВМР	RESPONSIBILITY	INSPECTION/MAINTENANCE ACTIVITIES	MINIMUM FREQUENCY	
Common Area Landscape Management	НОА	Maintenance shall be consistent with County requirements, plus fertilizer and/or pesticide usages shall be consistent with County guidelines for use of fertilizers and pesticides. Maintenance includes mowing, weeding, and debris removal on a weekly basis. Trimming, replanting and replacement of mulch shall be performed on an as-needed basis. Trimmings, clippings, and other waste shall be properly disposed of off-site in accordance with local regulations. Materials temporarily stockpiled during maintenance activities shall be placed away from water courses and drain inlets. Application of landscaping materials shall be limited to minimal amounts required and not within 48 hours prior to predicted rain events.	Weekly	
Common Area Litter Control	НОА	Litter patrol, violations investigation, reporting and other litter control activities shall be performed in conjunction with maintenance activities. Litter collection and removal shall be performed on a weekly basis.	Ongoing patrols. Weekly (minimum) pick up and removal.	
Street Sweeping Private Streets and Parking Lots	НОА	Streets and parking lots must be swept at least quarterly, including prior to the start of the rainy season (October 1st). Streets shall also be swept as needed.	Quarterly	

BMP In	BMP Inspection and Maintenance Responsibility/Frequency Matrix				
ВМР	RESPONSIBILITY	INSPECTION/MAINTENANCE ACTIVITIES	MINIMUM FREQUENCY		
Storm Water Quality Control Measur	res				
Proprietary Treatment Control Measures (T-6) – Filterra Unit	НОА	Inspect unit for accumulated sediment and debris, flow patterns, vegetation health and overall facility function; remove accumulated trash and debris, rake surface of filter bedding, replace top layer of mulch to maintain 3" height.	2-4 weeks during rainy season/after significant events. Custom frequency after 1-2 years observation		

ATTACHMENT E BMP INSPECTION MAINTENANCE RECORDS

ATTACHMENT F EDUCATIONAL MATERIALS

(Provided at Final Engineering)

ATTACHMENT G RWQCB APPROVAL LETTER





Los Angeles Regional Water Quality Control Board

October 9, 2017

Ms. Angela George Assistant Deputy Director County of Los Angeles Dept. of Public Works 900 South Fremont Avenue Alhambra, CA 91803

APPROVAL OF ALTERNATIVE BIOFILTRATION SPECIFICATION (FILTERRA BIORETENTION SYSTEM) PURSUANT TO PART VI.D.7.c.iii(1)(b)(i) OF THE LOS ANGELES COUNTY MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) PERMIT (NPDES PERMIT NO. CAS004001; ORDER NO. R4-2012-0175)

Dear Ms. George:

On January 17, 2017, the Los Angeles Regional Water Quality Control Board (Los Angeles Water Board) received a letter from the County of Los Angeles (County) requesting approval for the use of Filterra Bioretention Systems (Filterra) manufactured by Contech Engineered Solutions LLC as an alternative biofiltration specification.

The County's request includes an attachment that details a proposed design approach and equivalency criteria for Filterra to achieve equivalent performance to the conventional biofiltration design specifications defined in the Los Angeles County MS4 Permit.

Pursuant to Part VI.D.7.c.iii(1)(b)(i) of the Los Angeles County MS4 Permit, projects using biofiltration as an alternative compliance measure may use alternative design specifications for on-site biofiltration systems if approved by the Los Angeles Water Board Executive Officer.

Background

Part VI.D.7 of the Los Angeles County MS4 Permit requires Permittees to implement a Planning and Land Development Program. As part of this program, Permittees shall require all New Development and Redevelopment projects identified in Part VI.D.7.b (hereinafter "new projects") to control pollutants, pollutant loads, and runoff volume emanating from the project site. Except as provided in Part VI.D.7.c.ii (Technical Infeasibility or Opportunity for Regional Ground Water Replenishment), Part VI.D.7.d.i (Local Ordinance Equivalence), or Part VI.D.7.c.v (Hydromodification), each Permittee shall require new projects to retain on-site the Stormwater Quality Design Volume (SWQDv).

Pursuant to Part VI.D.7.c.iii.(1) of the Los Angeles County MS4 Permit, Permittees may allow new projects to use on-site biofiltration when the project applicant has demonstrated that it is technically infeasible to retain 100 percent of the Stormwater Quality Design Volume (SWQDv) on-site. If using biofiltration due to demonstrated technical infeasibility, then the new project must biofiltrate 1.5 times the portion of the SWQDv that is not reliably retained on-site, as calculated by the following equation:

$$Bv = 1.5 [SWQDv - Rv]$$

Where:

Bv = biofiltration volume

SWQDv = the stormwater runoff from a 0.75 inch. 24-hour storm or the 85th

percentile storm, whichever is greater Rv = volume reliably retained on-site.

As a condition for on-site biofiltration, bioretention/biofiltration systems shall meet the design specifications provided in Attachment H of the Los Angeles County MS4 Permit unless otherwise approved by the Los Angeles Water Board Executive Officer.

Public Review

On July 27, 2017, the Los Angeles Water Board provided public notice and a 30-day period to allow for public review and written comment on the proposed use of the Filterra alternative biofiltration design specification for new development and redevelopment projects. The Board received comments from APD Clean Water Technologies Group (APD) and Contech.

Los Angeles Water Board Review

Los Angeles Water Board staff reviewed the technical documents submitted by the County in their request and the issues raised during the public review period. In particular, APD's comment letter raised concerns regarding the performance of biofiltration and bioretention BMPs and the Los Angeles County MS4 Permit's compliance with best available technology economically achievable (BAT) and best conventional pollutant control technology (BCT) standards.

Los Angeles Water Board staff found that none of the information provided by APD directly challenged the suitability of the Filterra design as a biofiltration device, rather the comments pertained to the use of biofiltration and bioretention systems to comply with permit requirements in general. This concern is outside the scope of this action, since the Los Angeles County MS4 Permit establishes that biofiltration and bioretention systems are acceptable if the system meets the specific design specifications outlined in Attachment H of the permit. Furthermore, the BAT and BCT standards cited in the letter do not apply to MS4 discharges.

Alternative Biofiltration Specification Approval

I hereby approve the County's proposal for the use of Filterra as an alternative on-site biofiltration design specification pursuant to Part VI.D.7.c.iii(1)(b)(i) of the Los Angeles County MS4 Permit, provided the following conditions are met:

 Sizing: Filterra systems must be designed and sized following the methodology in Section 4 of the August 2015 report entitled "Filterra Equivalency Analysis and Design Criteria". Section 4 of this report is included as Attachment 1 of this letter.

- 2. **O&M**: Operation and maintenance of Filterra systems must be conducted consistent with the recommendations in the Filterra maintenance manual provided by the manufacturer and any revisions thereto.
- Media: Filterra systems use an engineered biofiltration media. Filterra systems, including the engineered biofiltration media, must be provided by the manufacturer. No substitution of materials/media is allowed.
- 4. Hydromodification: There is no presumption by this approval that a Permittee's implementation of the abovementioned design parameters and use specifications of the Filterra system meet the separate hydromodification requirements of Section VI.D.7.c.iv of the Los Angeles County MS4 Permit. Hydromodification requirements apply regardless of the type of biofiltration system used.

This approval only applies to the use of Filterra as an alternative on-site biofiltration design in situations where a project applicant has demonstrated that it is technically infeasible to retain 100 percent of the SWQDv on-site.

If you have any questions, please contact Mr. Chris Lopez of the Storm Water Permitting Unit at Chris.Lopez@waterboards.ca.gov or by phone at (213) 576-6674. Alternatively, you may also contact Ivar Ridgeway, Chief of the Storm Water Permitting Unit, at Ivar.Ridgeway@waterboards.ca.gov or by phone at (213) 620-2150.

Sincerely,

Samuel Unger, P.E.

Executive Officer

Enclosures:

Attachment 1 - Excerpt from Filterra Equivalency Analysis and Design Criteria

Report

cc: Mr. Paul Alva, County of Los Angeles

Attachment 1

Excerpt from Filterra Equivalency Analysis and Design Criteria Report

4 DESIGN METHODOLOGY AND EQUIVALENCY CRITERIA

In order to apply the equivalency relationships developed in Section 3, a standardized design methodology was developed. As a result of applying this design methodology, Filterra systems are expected to perform equivalently to conventional Attachment H biofiltration. This methodology consists of three parts, as described below.

Part A - Characterize Site and Determine Key Attributes

- 1. Delineate the tributary area to each Filterra BMP.
- 2. Estimate the imperviousness of the tributary area; use this value to estimate a runoff coefficient for use in stormwater quality design flowrate (SWQDf) and stormwater quality design volume (SWQDv) calculations. The runoff coefficient shall account for imperviousness and be based on standard methods acceptable to the reviewing jurisdiction.
- 3. Calculate the time of concentration (Tc) for each Filterra tributary area using methods acceptable to the local jurisdiction.
- 4. Estimate the long term reliable infiltration rate of the soils underlying each BMP location using appropriate methods, subject to the approval of the reviewing agency.
- 5. Determine local 85th percentile, 24-hour precipitation depth for the project. The 85th percentile, 24-hour rain event shall be determined from the Los Angeles County 85th percentile precipitation isohyetal map² or analysis of local long term precipitation data.
- 6. Calculate the SWQDv for each Filterra tributary area, using locally-approved methods.
- 7. Calculate the site "Scaling Factor" as the ratio of the project-specific 85th percentile, 24-hour storm event to the LAX 85th percentile, 24-hour storm event (1.02 inches).

Part B – Design Filterra for Equivalent Long Term Capture Efficiency

8. Consult Design Table 1 to determine the appropriate Filterra Design Precipitation Intensity associated with the Tc for each tributary area. For Tc less than 5 minutes, round up to 5 minutes. For Tc greater than 30 minutes, round down to 30 minutes. Interpolation between values in this table is permissible.

http://www.ladpw.org/wrd/publication/engineering/Final_Report-Probability_Analysis_of_85th_Percentile_24-br_Rainfall1.pdf

Design Table 1 - Filterra Design Chart for Equivalent Long Term Capture Efficiency

Time of Concentration of Tributary Area, minutes	Filterra Design Precipitation Intensity, inches per hour ¹
5	0.41
10	0.38
15	0.36
20	0.34
30	0.32

^{1 -} Sizing requirements are based on Filterra size required to achieve a target capture efficiency of 93% of long term runoff volume at the Los Angeles Airport gage. For different locations, the site scaling factor must be applied.

9. Apply the rational method to determine the design flowrate required for each Filterra.

$$Q_{required} = Runoff Coefficient (unitless) \times Filterra Design Precipitation Intensity (in/hr) \times Site Scaling Factor (unitless) \times Tributary Area (ac) \times (43560 sq-ft/ac/(12 in/ft × 3600 sec/hr))$$

10. Select a Filterra model with a treatment flow rate that is equal to or greater than the design flowrate based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area. This is equivalent to a treatment rate of 140 inches per hour.

Part C, Option 1 - Design for Equivalent Long Term Volume Reduction

The design of a Filterra system must mitigate for deficiency in volume reduction compared to conventional biofiltration. As one option, the designer may include supplemental infiltration, either upstream or downstream of the Filterra to compensate for the volume reduction deficit between conventional biofiltration and Filterra systems.

11. Consult Design Table 2 to determine the fraction of the SWQDv that needs to be provided in supplemental retention. It is appropriate to linearly interpolate within this table. For long term reliable infiltration rates greater than 0.3 inches per hour, full infiltration of the SWQDv must be considered.

Design Table 2 - Supplemental Infiltration Volume for Equivalent Long Term Volume Reduction

Estimated Long Term Reliable Infiltration Rate below Site, inches per hour	Long Term Volume Reduction Deficit, % of Long Term Runoff	Required Supplemental Infiltration Storage Volume as Fraction of Local SWQDv, unitless ¹	
0	3%	Not a feasible option; see Part C, Option 2	
0.01	5%	0.15	
0.05	10%	0.11	
0.15	21%	0.17	
0.3	34%	0.26	

^{1 –} Values are not expected to follow a continually increasing trend. A 2.1 foot effective depth is assumed for supplemental storage.

12. Multiply the site-specific SWQDv for each Filterra Tributary area calculated above by the ratio from Design Table 2 to determine the required supplemental retention volume. Design Table 2 is based on the assumption that the Contech ChamberMaxx product will be used, with an equivalent storage depth of 2.1 feet. Shallower or deeper storage would require different sizing factors. Supplemental calculations can be provided to demonstrate that an alternative storage configuration would provide equivalent long term volume reduction.

Part C, Option 2 - Design for Additional Capture In Lieu of Volume Reduction

As an alternative option, the designer may increase the size of the Filterra systems to provide additional capture in lieu of providing supplemental infiltration volume.

13. Consult Design Table 3 to determine the adjusted design precipitation intensity needed to compensate for volume reduction deficiency.

Design Table 3 - Upsizing of Filterra to Provide Additional Capture Efficiency in Lieu of Volume Reduction

	Site Infiltration Rate					
Time of Concentration of Tributary	0 in/hr Target Capture Efficiency = 93.8%	0.01 in/hr Capture Efficiency Target = 94.3%	0.05 in/hr Capture Efficiency Target = 95.5%	0.10 in/hr Capture Efficiency Target = 96.9%	0.15 in/hr Capture Efficiency Target = 98.3%	
Area, minutes	Adjusted Filterra Design Precipitation Intensities, in/hr					
5	0.44	0.46	0.52	0.66	NA	
10	0.41	0.43	0.48	0.58	NA	
15	0.39	0.41	0.45	0.53	0.76	
20	0.37	0.38	0.43	0.50	0.68	
30	0.34	0.35	0.39	0.46	0.56	

NA = additional capture is not a viable option to offset volume reduction in these cases.

- 14. Apply the rational method to determine the adjusted design flowrate required for each Filterra.
 - $Q_{required} = Runoff Coefficient (unitless) \times Adjusted Filterra Design Precipitation Intensity (in/hr) \times Site Scaling Factor (unitless) \times Tributary Area (ac) \times (43560 sq-ft/ac/(12 in/ft \times 3600 sec/hr))$
- 15. Select a Filterra model with a treatment flow rate that is equal or greater than Q_{required} based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area (140 inches per hour).

FILTERRA EQUIVALENCY ANALYSIS AND DESIGN CRITERIA

Pursuant to:

Los Angeles County MS4 Permit (Order R4-2012-0175)

Prepared for

CONTECH Engineered Solutions

Prepared by



engineers | scientists | innovators

621 SW Morrison Street, Suite 600 Portland, Oregon 97205

August 2015

TABLE OF CONTENTS

Table of	of Cor	ntents		i		
1	Intro	duction.		1		
2	BMP	MP descriptions				
	2.1	Conven	ntional Biofiltration	2		
	2.2	Filterra	Systems	2		
3	Basis	and Me	ethdology for Evaluating Equivalency	4		
	3.1	Basis fo	or Equivalency2	4		
	3.2		ls and Assumptions for Establishing Baseline Biofiltration			
		Perforn	nance	4		
		3.2.1	Hydrologic Performance (Capture Efficiency and Volume Reducti			
		3.2.2	Pollutant Treatment			
	3.3	Filterra	Analysis to Determine Equivalent Design Criteria			
		3.3.1	Capture Efficiency	5		
		3.3.2	Volume Reduction (Filterra and Supplemental Infiltration Storage)			
		3.3.3	Pollutant Treatment	8		
		3.3.4	Additional Capture In Lieu of Volume Reduction	9		
4	Desig	gn Meth	odology and Equivalency Criteria12	2		
5			nd Conclusions16			
	5.1	Key Ob	oservations and Findings16	5		
	5.2	Reliabi	lity and Limitations17	7		
6	Refe	rences		9		
Appen	dix A	- Conve	entional Biofiltration Design Assumptions for Performance Modelin	ng		
		21				
Appen			M Modeling Methodology and Assumptions			
	-	•	Scenarios 23			
			SWMM Analysis Framework 23			
	Mete	orologic	cal Inputs	5		
		Precipit	tation25	5		
		ET Para	ameters	5		
	Runc	off Paran	meters27	7		
	BMP	Repres	entation28	8		
		Conven	ntional Biofiltration	9		
		Filterra	. 30			
Appen	dix C	– Datas	ets and Analysis Methods for Pollutant Treatment Evaluation 32	2		
	Data	Develop	pment and Analysis Framework32	2		

Compilation and Screening of Conventional Biofiltration Studies	32
Screening Process for Developing Conventional Biofiltration Sample I	Pool32
Screening Results	35
Inventory of Bioretention Studies and Screening Results/Rationales	35
Compilation of Filterra Studies	36
Data Analysis Method	37
Land Use Stormwater Quality Inputs and Assumptions	38
Appendix D – Results of Pollutant Treatment Data Analysis	42

1 INTRODUCTION

The Los Angeles County MS4 Permit (Order No. R4-2012-0175) (MS4 Permit) defines "biofiltration" based on specific design and sizing criteria. In addition, the MS4 Permit allows the Los Angeles County Regional Water Quality Control Board (Regional Board) Executive Officer to approve alternate biofiltration design criteria. The purpose of this analysis was to develop a design basis for Filterra systems such that these systems will provide reasonably equivalent performance to biofiltration BMPs as defined in the MS4 Permit. This report is provided to the Executive Officer of the Regional Board to support approval of alternative design criteria for Filterra systems. This report describes the basis for evaluating equivalency, details the design approach and equivalency criteria for Filterra systems to achieve equivalent performance to conventional biofiltration, and provides the supporting rationales for these equivalency criteria.

The remainder of this report is organized as follows:

Section 2 – BMP Descriptions

Section 3 – Basis and Methodology for Evaluating Equivalency

Section 4 – Filterra Design Approach and Equivalency Criteria

Section 5 – Discussion and Conclusions

Section 6 – References

Appendix A – Design Assumptions for Conventional Biofiltration

Appendix B – SWMM Modeling Methodology and Assumptions

Appendix C – Datasets and Analysis Methods for Pollutant Treatment Evaluation

Appendix D – Results of BMP Treatment Performance Evaluation

-

¹ BMPs sized and designed per these criteria are referred to in this memorandum as "traditional biofiltration."

2 BMP DESCRIPTIONS

2.1 Conventional Biofiltration

Biofiltration (also known as bioretention with underdrain) consists of shallow landscaped depressions that capture and filter stormwater runoff through a planted engineered media. These facilities function as soil and plant-based filtration systems that remove pollutants through a variety of physical, biological, and chemical treatment processes. Biofiltration facilities normally consist of a ponding area, mulch layer, planting soils, and plantings (see typical schematic in Figure 1). An optional gravel layer added below the planting soil coupled with an upturned elbow (or similar hydraulic control approach) can provide additional storage volume for infiltration. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. As defined in Attachment H of the 2012 Los Angeles County MS4 Permit, biofiltration designs must meet a number of specific criteria to be considered "biofiltration" as part of compliance with the MS4 Permit. Conventional biofiltration is typically designed as a "volume-based" BMP, meaning that is it sized based on capture of the runoff from a specific size of storm event.

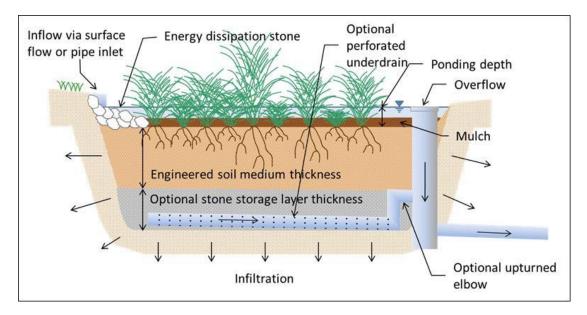


Figure 1. Cross sections of typical biofiltration system

2.2 Filterra Systems

Filterra systems include engineered filter media topped with mulch housed in a precast concrete curb inlet structure with a tree frame and grate cast in the top slab. In addition to the water quality filtering/sorption of stormwater, the engineered media and mulch supports the growth of a tree or other type of plant (see typical configuration in Figure 2). There are three key components of the Filterra system that contribute to pollutant removal: mulch, engineered filter media, and vegetation and other system biota. Filterra systems can be configured so that underdrains discharge into downstream retention storage systems. In contrast to conventional

biofiltration, the media filtration rates of Filterra systems are substantially higher, and therefore the footprint of these systems tends to be substantially smaller than conventional biofiltration systems. As a result of smaller footprints, the amount of volume reduction (via infiltration and evapotranspiration) that is typically observed in these systems when not coupled with infiltration systems tends to be relatively low. Because these systems provide relatively limited ponded water volume above the surface of the media, they are typically sized as "flow-based" BMPs based on a design intensity of rainfall rather than "volume-based" BMP based on a design storm depth.

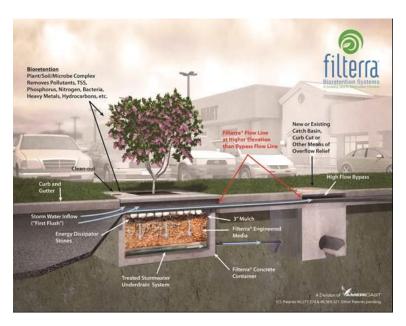


Figure 2. Diagram of the Filterra system (Contech, 2015 via web).

3 BASIS AND METHDOLOGY FOR EVALUATING EQUIVALENCY

3.1 Basis for Equivalency

Equivalency was evaluated between conventional biofiltration BMPs meeting the criteria of the MS4 Permit (specifically Attachment H) and Filterra systems as an alternate biofiltration BMP. Equivalency was determined based on the factors that influence the pollutant load reduction performance of stormwater BMPs:

- Capture efficiency: The percent of long term stormwater runoff volume that is "captured" and managed by the BMP (i.e., treated or reduced; not overflowed or bypassed).
- **Volume reduction**: The percent of long term stormwater runoff volume that is "lost" or "reduced" in the BMP to infiltration and evapotranspiration.
- **Concentration reduction**: For the volume that is treated and not reduced, the average difference in concentration between the influent volume and the treated effluent volume.

The equivalency analysis consisted of three parts:

- 1) The baseline performance of conventional biofiltration (capture efficiency, volume reduction, and concentration reduction) was estimated.
- 2) Applying the same methods as used to evaluate the performance of conventional biofiltration, sizing criteria were developed for Filterra (accompanied by supplemental infiltration systems, where needed) such that Filterra systems will provide equivalent performance to conventional biofiltration.
- 3) A design methodology for Filterra systems was developed to ensure consistent application of the equivalent sizing criteria in the design of Filterra systems.

The following subsections provide information about this analysis.

3.2 Methods and Assumptions for Establishing Baseline Biofiltration Performance

The following subsections summarize the methods and assumptions that were used to evaluate the baseline performance of conventional biofiltration BMPs consistent with Attachment H of the MS4 Permit.

3.2.1 Hydrologic Performance (Capture Efficiency and Volume Reduction)

Attachment H of the MS4 Permit specifies a number of criteria that influence the hydrologic performance of the conventional biofiltration BMPs:

- 6 to 18-inch ponding area above media
- Optional layer of mulch
- 2 to 3 feet of engineered filter media (2 feet typical) with a design infiltration rate of 5 to 12 inches/hour; the Attachment H specification calls for a mix of 60 to 80% fine sand and 20 to 40% compost

- Gravel storage layer below the bioretention media to promote infiltration
- Underdrain placed near the top of the gravel layer (or an infiltration sump otherwise provided via an equivalent hydraulic control approach) in cases where underlying soil allows incidental infiltration
- Underdrain discharge to the storm drain
- Capacity (including stored and filtered water) adequate to biofilter 150 percent of the portion of the SWQDv not reliably retained.

Within the bounds established by these criteria, a relatively wide range of actual biofiltration designs could result as a function of site infiltration conditions as well as designer and local jurisdiction preferences. An example of potential design variability is illustrated in Appendix A. For the purpose of this analysis, representative design assumptions were developed within the range of potential design assumptions. These assumptions are also presented in Appendix A with supporting rationales. Long term continuous simulation SWMM modeling was conducted using 15 years of 5-minute resolution precipitation data, as described in Appendix B, to estimate the long term capture efficiency and volume reduction of the baseline biofiltration design scenario for a range of site infiltration rates. Biofiltration BMPs will tend to provide more volume reduction when installed in sites with higher incidental infiltration rates. Table 1 describes the baseline hydrologic performance of biofiltration BMPs.

Table 1. Baseline Biofiltration Hydrologic Performance

	Long Term Capture Efficiency	Long Term Volume Reduction
Site Soil Infiltration Rate,	(percent of total runoff	(percent of total runoff
in/hr	volume)	volume) (ET + Infiltration)
0		4%
0.01	92 to 94% ¹	6%
0.05	(93% capture is	11%
0.15	representative)	22%
0.30^2		35%

^{1 -} Capture efficiency varies slightly as a function of soil infiltration rate (and associated differences in design profile) and land use imperviousness. These differences are relatively minor and are considered to be less important than the variability in performance that may result from different design approaches and maintenance conditions that may be encountered. Therefore a single baseline value of 93 percent long term capture was used in this analysis.

3.2.2 Pollutant Treatment

Pollutant treatment performance was evaluated based on analysis of bioretention with underdrain studies in the International Stormwater BMP Databases. Analyses were conducted based on all studies (28 studies) and a screened subset of studies that were considered to be most representative of Attachment H design criteria (16 studies). Additionally, two recent studies from the University of Maryland were added which followed rigorous protocols and evaluated systems sharing many similarities to Attachment H design criteria. Biofiltration research in California is very limited. Two recent monitoring studies were conducted in the San Francisco Bay area (led

^{2 -} A maximum soil infiltration rate of 0.3 inches per hour was evaluated because for soil infiltration rates greater than 0.3 inches per hour the MS4 Permit requires that infiltration be evaluated.

by the San Francisco Estuary Institute) on systems with media composition, sizing and design that would conform to Attachment H of the Los Angeles MS4 Permit. While these studies did not collect flow weighted composite influent and effluent samples, they were included in the data set.

Treatment performance was characterized using a moving window bootstrapping method that accounts for the influence of influent concentration on effluent concentration and characterizes the relative uncertainty in performance estimates within each range of influent quality. Both the median and mean summary statistics were evaluated using these methods. Additionally, literature on the influence of biofiltration design variables on performance was summarized to support the criteria that were used to select the 20 BMP studies that were included in the screened dataset. The pollutant treatment evaluation was based on total suspended solids, total phosphorus, total nitrogen, total copper, and total zinc. Influent concentrations characteristic of single family, multi family, commercial, and light industrial land uses were applied to estimate effluent concentrations and concentration change.

Generally, biofiltration provided good removal of TSS, moderate removal of copper and zinc, and generally showed export of nutrients. Export of nutrients tended to be greater when influent concentrations were low. Also, the dataset that was screened to include studies more similar to Attachment H design criteria (i.e., 5 to 12 inches per hour, with compost) showed substantially greater frequency of observed export of nutrients.

Details about pollutant treatment analyses are provided in Appendix C, and results of these analyses are provided in Appendix D.

3.3 Filterra Analysis to Determine Equivalent Design Criteria

The following paragraphs describe the analyses that were conducted for Filterra systems to determine the sizing criteria under which Filterra systems provide equivalent performance to conventional biofiltration.

3.3.1 Capture Efficiency

Filterra capture efficiency is a function of the design precipitation intensity used in sizing the Filterra system and the time of concentration (Tc) of the tributary area. Continuous simulation modeling using the SWMM model, with 15 years of 5-minute resolution precipitation, as described in Appendix B, was used to determine the relationship between design precipitation intensity, Tc, and long term capture efficiency (Figure 3). Based on this chart, the design guidance presented in Section 4 requires that approved methods, appropriate for the site, are used for calculating Tc and selecting a runoff coefficient equation to convert the design intensity to a design flowrate.

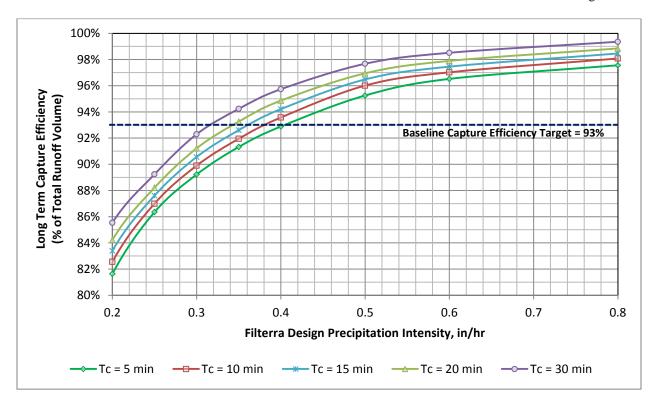


Figure 3. Chart of Filterra Capture Efficiency

3.3.2 Volume Reduction (Filterra and Supplemental Infiltration Storage)

Filterra systems, sized within the range needed to match conventional biofiltration capture efficiency, were estimated to provide approximately 1 percent long term volume reduction via evapotranspiration from soil pores (determined from SWMM modeling described above). This relatively small value is a function of the relatively small surface area of typical Filterra systems.

For site conditions in which conventional biofiltration BMPs would achieve appreciable volume reduction, supplemental infiltration systems (located either upstream or downstream of Filterra systems) may be needed to result in volume reduction equal to what would be achieved by conventional biofiltration BMPs under the same site conditions. Volume reduction is a function of the storage volume provided, the surface area of the storage/soil interface, and the infiltration rate of the soil (and associated drawdown time of the stored water). As described in Appendix B, SWMM modeling was conducted to determine the long term volume reduction of supplemental infiltration storage as a function of storage volume (with a reasonable surface area) and soil infiltration rate (Figure 4). The supplemental retention volume is specified as a fraction of the site-specific SWQDv, which is a standardized calculation in each jurisdiction and accounts for different precipitation depths around Los Angeles County as well as infiltration rates. The design methodology (Section 4) also provides guidance about the allowable depth of the supplemental retention storage systems so that stored water will infiltrate in a reasonable amount of time.

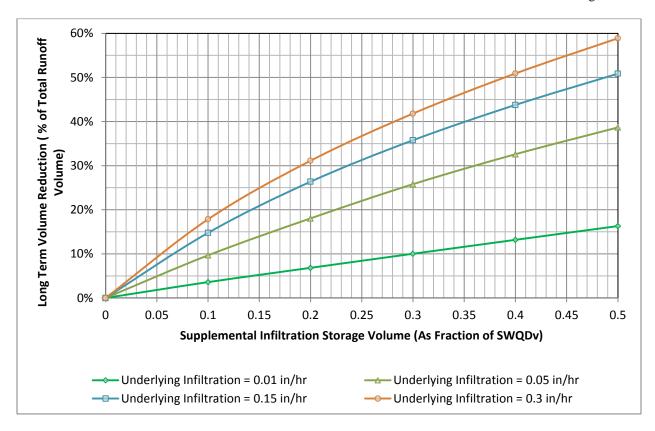


Figure 4. Chart of Volume Reduction in Supplemental Infiltration Storage

3.3.3 Pollutant Treatment

Filterra performance data were analyzed using the same moving window bootstrapping methods used for conventional biofiltration. Data from 6 third party studies conducted over the last 11 years (including some studies monitored periodically since 2007) were utilized in this analysis. This analysis sought to determine whether Filterra performance is reasonably similar to the treatment performance of conventional biofiltration BMPs under representative ranges of influent quality. This analysis was based on the same pollutant and land uses described above for conventional biofiltration.

The following bullets summarize the comparison of pollutant concentration reduction for conventional biofiltration and Filterra systems. Detailed comparison tables and plots are provided in Appendix D.

- **TSS:** Filterra performed somewhat better than conventional biofiltration systems for TSS across all representative land use concentrations considered. Both systems showed relatively strong performance for TSS.
- Copper and Zinc: Performance was generally similar between Filterra and conventional biofiltration for copper and zinc. Filterra showed better performance for some representative influent concentrations and conventional biofiltration showed better concentration reductions for others. In general, both provided moderate concentration

reductions of metals. The sample size for Filterra for sites with high metals concentrations is somewhat small, which results in wider confidence intervals for land uses with higher concentrations. Specifically, there was only one study (Port of Tacoma TAPE, station POT2) that had high zinc concentrations; this site was notable/unique in its high concentrations and the degree of dissolved zinc as a fraction of total zinc. For this site, average zinc influent concentrations were approximately 1,000 ug/L of which approximately 85 percent was dissolved zinc, on average. The concentration reductions for this site were still moderate (approximately 50 percent average removal).

• Nitrogen and Phosphorus: Filterra systems appear to provide much better pollutant concentration reduction than conventional biofiltration for nitrogen and phosphorus. Filterra does not appear to exhibit the export issues that were noted for conventional biofiltration within the representative range of land use concentrations considered. Variability in pollutant reduction performance was also lower for Filterra.

Given these findings, Filterra are expected to provide similar or better pollutant concentration reduction for all pollutants across the representative site conditions considered.

3.3.4 Additional Capture In Lieu of Volume Reduction

As described in Section 3.3.2 and Section 4, one approach for matching the pollutant load reduction of conventional biofiltration is to provide supplemental infiltration storage upstream or downstream of Filterra systems to match the volume reduction that would be achieved by conventional biofiltration.

For Filterra applications with minor deficiencies in volume reduction compared to conventional biofiltration, another option is to capture and treat additional long term runoff volume (via increased sizing) to achieve equivalent load reductions in lieu of providing supplemental infiltration storage. As a simple approach for minor volume reduction deficiencies, the pollutant treatment performance of Filterra systems for TSS was used as a simple method. Based on a minimum removal efficiency of 80 percent (actual performance is expected to be higher), a BMP must treat and discharge 5 parts of water for every 4 parts of water that would be lost to infiltration or ET. This means that for every 1 percent of volume reduction deficit, 1.25 percent of long term volume must be treated or 0.25 percent additional capture for every 1 percent of volume reduction deficit. This concept is illustrated in Figure 5. Calculations of required additional capture efficiency are provided in Table 2.

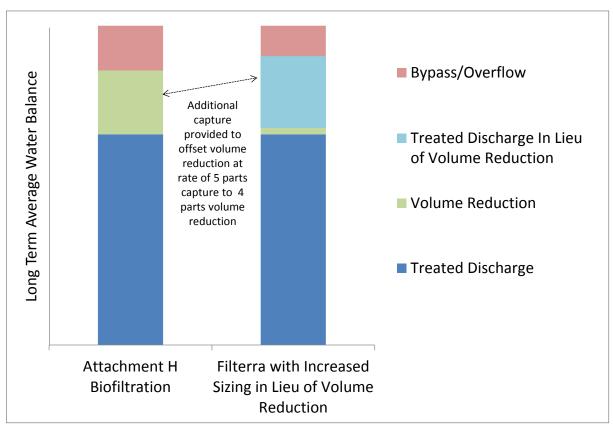


Figure 5. Illustration of Additional Capture In Lieu of Volume Reduction (Not to scale)

Table 2. Additional Capture Efficiency in Lieu of Volume Reduction

			111 2100 01 1 0101	1110 110000001011	
				Additional	
	Attachment H			Capture	
	Biofiltration	Filterra Long		Efficiency	Adjusted
Site Soil	Long Term	Term Volume	Volume	in Lieu of	Target
Infiltration Rate,	Volume	Reduction ¹	Reduction	Volume	Capture
in/hr	Reduction ^{1, 2}	(ET only)	Deficit	Reduction ³	Efficiency
0	4%	1%	3%	0.8%	93.8%
0.01	6%	1%	5%	1.3%	94.3%
0.05	11%	1%	10%	2.5%	95.5%
0.10	16.5%	1%	15.5%	3.9%	96.9%
0.15	22%	1%	21%	5.3%	98.3%
0.30	35%	1%	34%	8.5%	N/A

^{1 –} Based on modeling of ET from soil pores and standing water.

^{2 –} Includes infiltration losses, where feasible

^{3 –} Required additional capture calculated at a rate of 1 part additional for every 4 parts volume reduction deficit.

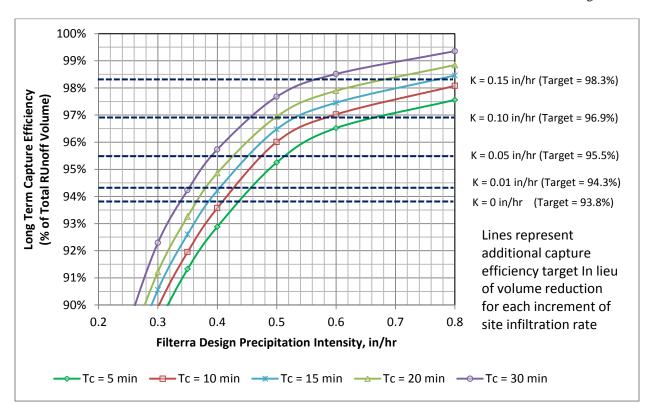


Figure 6. Additional Capture Targets In Lieu of Volume Reduction (same chart as Figure 4, with adjusted axis limits)

4 DESIGN METHODOLOGY AND EQUIVALENCY CRITERIA

In order to apply the equivalency relationships developed in Section 3, a standardized design methodology was developed. As a result of applying this design methodology, Filterra systems are expected to perform equivalently to conventional Attachment H biofiltration. This methodology consists of three parts, as described below.

Part A - Characterize Site and Determine Key Attributes

- 1. Delineate the tributary area to each Filterra BMP.
- 2. Estimate the imperviousness of the tributary area; use this value to estimate a runoff coefficient for use in stormwater quality design flowrate (SWQDf) and stormwater quality design volume (SWQDv) calculations. The runoff coefficient shall account for imperviousness and be based on standard methods acceptable to the reviewing jurisdiction.
- 3. Calculate the time of concentration (Tc) for each Filterra tributary area using methods acceptable to the local jurisdiction.
- 4. Estimate the long term reliable infiltration rate of the soils underlying each BMP location using appropriate methods, subject to the approval of the reviewing agency.
- 5. Determine local 85th percentile, 24-hour precipitation depth for the project. The 85th percentile, 24-hour rain event shall be determined from the Los Angeles County 85th percentile precipitation isohyetal map² or analysis of local long term precipitation data.
- 6. Calculate the SWQDv for each Filterra tributary area, using locally-approved methods.
- 7. Calculate the site "Scaling Factor" as the ratio of the project-specific 85th percentile, 24-hour storm event to the LAX 85th percentile, 24-hour storm event (1.02 inches).

Part B – Design Filterra for Equivalent Long Term Capture Efficiency

8. Consult Design Table 1 to determine the appropriate Filterra Design Precipitation Intensity associated with the Tc for each tributary area. For Tc less than 5 minutes, round up to 5 minutes. For Tc greater than 30 minutes, round down to 30 minutes. Interpolation between values in this table is permissible.

http://www.ladpw.org/wrd/publication/engineering/Final Report-Probability Analysis of 85th Percentile 24-hr Rainfall1.pdf

Time of Concentration of Tributary Area, minutes	Filterra Design Precipitation Intensity, inches per hour ¹
5	0.41
10	0.38
15	0.36
20	0.34
30	0.32

^{1 -} Sizing requirements are based on Filterra size required to achieve a target capture efficiency of 93% of long term runoff volume at the Los Angeles Airport gage. For different locations, the site scaling factor must be applied.

9. Apply the rational method to determine the design flowrate required for each Filterra.

$$Q_{required} = Runoff\ Coefficient\ (unitless) \times Filterra\ Design\ Precipitation\ Intensity\ (in/hr) \times Site\ Scaling\ Factor\ (unitless) \times Tributary\ Area\ (ac) \times (43560\ sq-ft/ac/(12\ in/ft \times 3600\ sec/hr))$$

10. Select a Filterra model with a treatment flow rate that is equal to or greater than the design flowrate based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area. This is equivalent to a treatment rate of 140 inches per hour.

Part C, Option 1 - Design for Equivalent Long Term Volume Reduction

The design of a Filterra system must mitigate for deficiency in volume reduction compared to conventional biofiltration. As one option, the designer may include supplemental infiltration, either upstream or downstream of the Filterra to compensate for the volume reduction deficit between conventional biofiltration and Filterra systems.

11. Consult Design Table 2 to determine the fraction of the SWQDv that needs to be provided in supplemental retention. It is appropriate to linearly interpolate within this table. For long term reliable infiltration rates greater than 0.3 inches per hour, full infiltration of the SWQDv must be considered.

Design Table 2 - Supplemental Infiltration Volume for Equivalent Long Term Volume Reduction

Estimated Long Term Reliable Infiltration Rate below Site, inches per hour	Long Term Volume Reduction Deficit, % of Long Term Runoff	Required Supplemental Infiltration Storage Volume as Fraction of Local SWQDv, unitless ¹
0	3%	Not a feasible option; see Part C, Option 2
0.01	5%	0.15
0.05	10%	0.11
0.15	21%	0.17
0.3	34%	0.26

^{1 –} Values are not expected to follow a continually increasing trend. A 2.1 foot effective depth is assumed for supplemental storage.

12. Multiply the site-specific SWQDv for each Filterra Tributary area calculated above by the ratio from Design Table 2 to determine the required supplemental retention volume. Design Table 2 is based on the assumption that the Contech ChamberMaxx product will be used, with an equivalent storage depth of 2.1 feet. Shallower or deeper storage would require different sizing factors. Supplemental calculations can be provided to demonstrate that an alternative storage configuration would provide equivalent long term volume reduction.

Part C, Option 2 - Design for Additional Capture In Lieu of Volume Reduction

As an alternative option, the designer may increase the size of the Filterra systems to provide additional capture in lieu of providing supplemental infiltration volume.

13. Consult Design Table 3 to determine the adjusted design precipitation intensity needed to compensate for volume reduction deficiency.

Design Table 3 - Upsizing of Filterra to Provide Additional Capture Efficiency in Lieu of Volume Reduction

	Site Infiltration Rate				
Time of	0 in/hr Target Capture	0.01 in/hr Capture Efficiency	0.05 in/hr Capture Efficiency	0.10 in/hr Capture Efficiency	0.15 in/hr Capture
Concentration of Tributary	Efficiency = 93.8%	Target = 94.3%	Target = 95.5%	Target = 96.9%	Efficiency Target = 98.3%
Area, minutes	Adjusted Filterra Design Precipitation Intensities, in/hr				
5	0.44	0.46	0.52	0.66	NA
10	0.41	0.43	0.48	0.58	NA
15	0.39	0.41	0.45	0.53	0.76
20	0.37	0.38	0.43	0.50	0.68
30	0.34	0.35	0.39	0.46	0.56

NA = additional capture is not a viable option to offset volume reduction in these cases.

- 14. Apply the rational method to determine the adjusted design flowrate required for each Filterra.
 - $Q_{required} = Runoff\ Coefficient\ (unitless) \times Adjusted\ Filterra\ Design\ Precipitation Intensity\ (in/hr) \times Site\ Scaling\ Factor\ (unitless) \times Tributary\ Area\ (ac) \times (43560\ sq-ft/ac/(12\ in/ft \times 3600\ sec/hr))$
- 15. Select a Filterra model with a treatment flow rate that is equal or greater than Q_{required} based on a maximum treatment flow rate of 1.45 gallons per minute per square foot of Filterra surface area (140 inches per hour).

5 DISCUSSION AND CONCLUSIONS

5.1 Key Observations and Findings

This analysis and associated research yielded a number of key observations:

- The baseline level of capture efficiency and volume reduction provided by conventional biofiltration BMPs, if effectively designed per Attachment H, is relatively high. This establishes a relatively high baseline standard for Filterra systems to meet in providing equivalent performance.
- There is substantial leeway within the Attachment H criteria and local implementation guidance that is expected to result in design variations of conventional biofiltration throughout Los Angeles County. These variations are expected to result in fairly important variations in hydrologic performance. Additionally, variations in operations and maintenance conditions over time (i.e., decline in media rates, reduction in active storage volume from sedimentation) are also expected to influence performance.
- It is possible to design Filterra systems to match the capture efficiency of conventional biofiltration BMPs. This requires larger sizes of Filterra systems than was required for treatment control BMPs under the previous MS4 Permit. This also requires a commitment to regular maintenance consistent with Filterra standard maintenance requirements.
- Filterra systems alone are not expected to match the volume reduction performance provided by conventional biofiltration that is effectively designed, even in lined systems. However, it is possible for Filterra systems to mitigate for deficiency in volume reduction via either supplemental infiltration storage or increasing the size of Filterra systems to increase their capture efficiency thereby providing equivalent load reductions.
- For water that is treated and released, Filterra performance studies generally showed similar or better concentration reduction compared to conventional biofiltration. Filterra performance tended to be less variable in most cases. Filterra systems also did not exhibit the potential for major nutrient export that is relatively common in conventional biofiltration.
- When studies from the International BMP Database were screened to best match conventional biofiltration designs per Attachment H (specifically compost and sand fractions), the treatment performance tended to decline somewhat. This is consistent with findings related to use of compost in biofiltration media from other studies. This indicates that there is still progress to be made in addressing nutrient export issues in conventional biofiltration systems. For example, in Western Washington results of rigorous testing of media comprised of sand and compost conforming to local specifications have led to limitations on the use of biofiltration in nutrient sensitive watersheds and have stimulated research into alternative media blends.

Overall, if Filterra systems are designed based on the methodology and criteria presented in Section 4 and effectively operated and maintained these systems are expected to match or exceed the performance of conventional biofiltration within a reasonable margin of uncertainty.

5.2 Reliability and Limitations

There are a number of uncertainties that influence the reliability of the findings presented in this report. These are addressed in the paragraphs below.

Modeled hydrologic performance estimates. Performance estimates were based on models which were not calibrated. This introduces some uncertainty. This uncertainty was mitigated by applying identical input parameters and modeling approaches for conventional biofiltration and Filterra systems, as appropriate. This has the effect of offsetting the majority of potential sources of bias.

Treatment performance estimates for conventional biofiltration. Treatment performance estimates were based on peer reviewed studies from the International BMP Database and other peer reviewed third party studies that were selected to be representative of the BMPs being compared. Due to limited sample size of conventional biofiltration monitoring studies and some deficiencies in documentation of these studies, it was not possible to quantitatively evaluate whether performance estimates are specifically representative of Attachment H biofiltration. Additionally, performance has been observed to vary greatly from site to site, indicative of the importance of design factors such as sizing, media composition, sources of media components, and other design factors. The screened and unscreened datasets analyzed are believed to provide reliable information about the range of potential performance that may be expected from conventional biofiltration in Los Angeles County; however they are not intended to be used as a predictive tool for any one variation of biofiltration design. Reliability of these data was improved through the application of robust statistical methods that account for the influence of influent concentration and provide a quantification of uncertainty.

Treatment performance estimates for Filterra systems. Filterra systems have been evaluated in a range of sites and climates; however none of these sites were in Los Angeles and not all studies are necessarily representative of the influent quality from typical Los Angeles land uses. Additionally, the sample size of Filterra datasets is still somewhat low in comparison to conventional biofiltration BMPs. These factors are mitigated to a large extent by the standardized design that accounts for rainfall intensity/duration differences and ensures consistency in media composition of Filterra systems. These factors improve the transferability of findings between regions. Additionally, the reliability of Filterra performance data was improved by applying the same robust statistical methods as used for conventional biofiltration, which help adjust for differences in influent quality between studies.

TSS removal as a surrogate for additional capture in lieu of volume reduction. For small deficiencies in volume reduction, a TSS treatment removal rate of 80 percent was used to calculate required additional capture efficiency in lieu of volume reduction. A multi-parameter approach would be more complex and would need to account for the export of nutrients in conventional biofiltration as well as the observation that metals performance

tends to vary substantially with influent concentration (i.e., where influent concentration is relatively low, the removal efficiency tends to be lower, but the resulting effluent concentration is still below typical water quality standards). Given that this approach is only intended to offset minor volume reduction (up to about 20%), this is considered to be a reasonable approach.

Sensitivity to site conditions. The effectiveness of volume reduction processes is particularly sensitive to estimates of site infiltration rate. It may not be possible to anticipate, with certainty, what the final long term infiltration rate will be in the post construction condition. This limitation is largely mitigated for the purpose of this analysis because the uncertainty in infiltration rate influences the design and performance of conventional biofiltration and Filterra with infiltration storage similarly. Additionally, estimating the site infiltration rate is now a standard part of developing a BMP plan for a site, therefore approaches for developing this estimate should improve in reliability with time. Finally, both systems provide excellent TSS treatment prior to infiltration and long term infiltration rates should therefore be more reliable.

Variability in design and construction process. The analyses and criteria presented in this report are based on the assumption that the BMPs will be effectively designed and constructed consistent with a typical standard of care. It is inherent that design of non-proprietary conventional biofiltration BMP provides a greater degree of freedom and associated professional judgment as part of preparing design calculations, design drawings, and specifications. This introduces a wider potential range of resulting designs. Some may be better than average, some may be worse. Additionally, there are typically a number of specialized elements in the construction of a biofiltration BMP that may introduce variability in as-built condition as a result of contractor preferences and/or quality control issues. There are many examples of biofiltration facilities that have failed due to design and construction issues. In comparison, there is likely to be substantially less variability in the design and construction of Filterra system compared to biofiltration BMPs.

Sensitivity to operations and maintenance. Both types of systems are susceptible to decline in performance over time. Neither system will work if they are not regularly and effectively maintained. Filterra systems may be more susceptible to rapid clogging because of their relatively small footprint. However, this is mitigated by Filterra having a standard maintenance plan that has been informed by feedback from O&M of numerous facilities.

Overall, the analyses are believed to result in reliable design assumptions. Where substantial uncertainties exist, the analyses and assumptions have tended to err on the side of estimating somewhat higher performance for conventional biofiltration and somewhat lower performance for Filterra systems, which likely results in more conservatism in Filterra equivalency sizing.

6 REFERENCES

- Americast, Inc. 2009a. Filterra[®] Flow Rate Longevity Verification Study. May 2009.
- Americast, Inc. 2009b. Filterra® Long Term Field Performance Evaluation Report. April 2009.
- ATR Associates. 2009. Technical Report Addendum. Additional Field Testing and Statistical Analysis of the Filterra® Stormwater Bioretention Filtration System. Prepared for Americast, Inc. by Richard Stanford, ATR Associates, Inc., Strasburg, Virginia. January 26, 2009.
- Automated surface Observing System (ASOS). (2015). ftp://ftp.ncdc.noaa.gov/pub/data/asos-fivemin/.
- California Department of Water Resources (CDWR). (2015). California Irrigation Management Information System (CIMIS). Website: http://www.cimis.water.ca.gov/.
- David N., Lent, M., Leatherbarrow, J., Yee, D., and McKee, L. (2011). Bioretention Monitoring at the Daly City Library. Final Report. Contribution No. 631. San Francisco Estuary Institute, Oakland, California.
- Davis, A. P. (2007). "Field Performance of Bioretention: Water Quality." Environ. Eng. Sci. 2007, 24, 1048–1063.
- Davis, A., Traver, R., Hunt, W., Lee, R., Brown, R., and Olszewski, J. (2012). "Hydrologic Performance of Bioretention Storm-Water Control Measures." J. Hydrol. Eng., 17(5), 604–614.
- Gilbreath, A. N., Pearce, S. P. and McKee, L. J. (2012). Monitoring and Results for El Cerrito Rain Gardens. Contribution No. 683. San Francisco Estuary Institute, Richmond, California.
- Herrera (2009). Filterra Bioretention Filtration System Performance Monitoring Technical Evaluation Report. Prepared for Americast, Inc. by Herrera Environmental Consultants, Inc., Seattle, Washington. December 3, 2009.
- Herrera (2014a). Technical Evaluation Report: Filterra System Phosphorus Treatment and Supplemental Basic Treatment Performance Monitoring. Prepared for: Americast, Inc. (as art of TAPE Process) by Herrera Environmental Consultants, Inc., Seattle, Washington. February 12, 2014
- Herrera (2014b). Final Report: 185th Avenue NE Bioretention Stormwater Treatment System Performance Monitoring. Prepared for City of Redmond, by Herrera Environmental Consultants, Inc., Seattle, Washington. March 6, 2014.
- Herrera (2015a). Interim Project Report: City of Redmond Six Bioretention Swales Monitoring. Prepared for City of Redmond, by Herrera Environmental Consultants, Inc., Seattle, Washington. February 20, 2015
- Herrera (2015b). Analysis of Bioretention Soil Media for Improved Nitrogen, Phosphorous and Copper Retention, Final Report, Prepared for Kitsap County by Herrera Environmental Consultants, Seattle, WA, July 17, 2015.
- Geosyntec Consultants and Wright Water Engineers (2009). Urban Stormwater BMP Performance Monitoring. Prepared by Geosyntec Consultants and Wright Water Engineers, Inc. Prepared under Support from U.S. Environmental Protection Agency, Water Environment Research Foundation, Federal Highway Administration, Environmental and

- Water Resources Institute of the American Society of Civil Engineers. October 2009. http://www.bmpdatabase.org/Docs/2009%20Stormwater%20BMP%20Monitoring%20Manu al.pdf
- Los Angeles County (LA County), 2000. Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report.
- Los Angeles County (LA County), 2001. Los Angeles County 2000-2001 Stormwater Monitoring Report.
- Los Angeles County (LA County), 2006. Los Angeles County Hydrology Manual, Department of Public Works (LACDPW), Alhambra, California
- Larry Walker Associates and Geosyntec Consultants, 2011. Ventura County Technical Guidance Manual for Stormwater Quality Control Measures. July 2011.
- Leisenring, M., Poresky, A., Strecker, E., and M. Quigley, 2009. Evaluating Paired BMP Influent and Effluent Data Using Running Bootstrap Medians. Proceedings of the American Water Resources Association Annual Conference, Seattle WA, November 9-12, 2009.
- Li, H. and Davis, A. (2009). "Water Quality Improvement through Reductions of Pollutant Loads Using Bioretention." J. Environ. Eng., 135(8), 567–576.
- National Climatic Data Center (NCDC). (2015). ftp://ftp.ncdc.noaa.gov/pub/data/hourly_precip-3240/.
- North Carolina State University 2015. Filterra Bioretention System Sediment Removal and Hydrologic Performance Evaluation Report, Fayetteville Amtrak Filterra® Prepared for: Filterra® Bioretention Systems. August 28, 2014. Prepared by Andrew Anderson and Andrea Smolek.
- Roseen, R.M. and Stone, R.M. (2013). Bioretention Water Quality Treatment Performance Assessment. Technical Memorandum. Prepared for Seattle Public Utilities.
- Singh, K. and Xie, M. (2008) Bootstrap: a statistical method. Rutgers University.
- Yu and Stanford. 2006. Field Evaluation of the Filterra® Stormwater Bioretention Filtration System. A Final Technical Report. Prepared for Americast, Inc. by Dr. Shaw L. Yu and Richard L. Stanford, Department of Civil Engineering, University of Virginia. May 24, 2006.
- Washington State Department of Ecology. 2014. 2012 Stormwater Management Manual for Western Washington (as Amended in 2014. Publication Number 14-10-055.

.

APPENDIX A – CONVENTIONAL BIOFILTRATION DESIGN ASSUMPTIONS FOR PERFORMANCE MODELING

The following criteria from Attachment H were considered to be important for evaluating pollutant load reduction performance of "conventional biofiltration" scenarios:

- 6 to 18-inch ponding area above media
- Optional layer of mulch
- 2 to 3 feet of engineered filter media (2 feet typical) with a design infiltration rate of 5 to 12 inches/hour; the Attachment H specification calls for a mix of 60 to 80% fine sand and 20 to 40% compost
- Gravel storage layer below the bioretention media to promote infiltration
- Underdrain placed near the top of the gravel layer (or an infiltration sump otherwise provided via an equivalent hydraulic control approach) in cases where underlying soil infiltration rates allow
- Underdrain discharge to the storm drain
- Total physical water storage volume sized to be equal to at least the stormwater quality design volume (SWQDv = runoff volume from the 85th percentile, 24-hour storm event)
- Capacity (including stored and filtered water) adequate to biofilter 150 percent of the portion of the SWQDv not reliably retained.

Within the bounds established by these criteria, a relatively wide range of actual biofiltration designs could result as a function of site infiltration conditions as well as designer and local jurisdiction preferences. An example of potential design variability is illustrated in Table A.1 below. For the purpose of this analysis, representative design assumptions were developed within the range of potential design assumptions. These assumptions are also presented in Table A.1 with supporting rationales.

Table A.1 Biofiltration Design Assumptions from Various Sources and Selected Representative Design Assumptions

	Design References						
Design Assumption	MS4 Permit Attachment H	Los Angeles County LID Manual, static method	Los Angeles County LID Manual, routing method	City of Los Angeles LID Manual	Ventura County TGM	Selected Representative Design Assumption	Rationale for Selected Design Assumption
Ponding Depth, ft	0.5 to 1.5	0.5 to 1.5	0.5 to 1.5	0.5 to 1.5	0.5 to 1.5	1.5	Many designers will utilize deepest depth allowable because of space efficiency.
Media Depth, ft	2 to 3	2 to 3	2 to 3	2 to 3	2 to 3	2	Typical design approach is to use minimum depth due to cost of media.
Gravel "sump" depth below underdrain, ft	Not specified; narrative	Not specified, narrative	Not specified, narrative	At least 1 feet; up to 2 feet if soils allow incidental infiltration	0.5 minimum below underdrain	Depth that would drain in 24 hours. For example, 1.5 ft if site infiltration rate estimated at just less than 0.3 in/hr	Approach produces a reasonable design that considers infiltration rates; Attachment H states that volume infiltrated within 24 hours can be considered retained.
Media Filtration Rate, in/hr	5 to 12	5 to 12	5 to 12	5 to 12	1 to 12 (5)	5	Representative of long term operation after some clogging
Allowable Routing Period for Biofiltration Treatment, hrs	Not specified	Routing is not part of simple method	Allows routing of 24-hour design hydrograph from LA County HydroCalc model	3 hours, unless using a routing model	Depth up to ponding depth (1.5 ft) can be considered routed	6 hours ¹	Based on evaluation of storm durations for events similar to design event. See footnote 1.
Resulting Footprint Factor at 0.3 in/hr Infiltration Rate, in/hr (% of impervious area)	Not enough information to calculate	7.5%	1.4%	2.4% (1.4% with routing similar to LA County)	2.8%	2.0%	Calculated based on assumptions.

Note: where a range of guidance is allowed, the bolded number indicates the value that was used in calculations. The design values were selected based on developing the most economical and space-efficient design that meets the applicable criteria.

1 – The allowable routing period was estimated based on the typical storm duration associated with events similar to the 85th percentile, 24-hour storm depth (1.0 inches at LAX). This was estimated in two ways. For days with precipitation totals between 0.9 and 1.1 inches, the total number of hours with rainfall was tabulated (average = 11 hours; 10th percentile = 6 hours). This does not consider dry periods between hours with rainfall, therefore is somewhat conservative in estimating the period of time available for routing biofiltered water during a given day. For unique precipitation events, separated by 6 hour dry period (potentially spanning across breaks in calendar days), with precipitation totals between 0.9 and 1.1 inches, the total storm durations were tabulated (average = 16 hours; 10th percentile = 7 hours). Based on this analysis, a 6 hour routing period is considered to be defensible and conservative in estimating the amount of water that can be routed through a biofiltration system during typical storm events similar to the design storm event.

APPENDIX B – SWMM MODELING METHODOLOGY AND ASSUMPTIONS

Equivalency Scenarios

The relative performance of Filterra systems and conventional biofiltration was compared under the following climate and site conditions:

- Climate (and associated precipitation and ET): Los Angeles
- Land Use (and associated imperviousness and runoff quality): Multi-family Residential
- Soil infiltration rate: 0, 0.01, 0.05, 0.15, and 0.3 inches per hour
- A hypothetical 1-acre catchment was used for this analysis and was not varied.

For conventional biofiltration, the sizing and design criteria described in Appendix A were followed.

For Filterra systems, all combinations of the following sizing criteria were evaluated for each combination of climate and site conditions:

- Design precipitation intensity: 10 sizing increments were evaluated between 0.1 and 0.8 inches per hour.
- Catchment time of concentration: 5 increments were evaluated between 5 minutes and 30 minutes
- Downstream retention storage volume: 5 increments were evaluated between 0% (absent) and 50% of the runoff from the 85th percentile, 24-hour storm event.

Specific SWMM modeling representations of each combination of site conditions and BMP parameters are described in this Appendix.

Overview of SWMM Analysis Framework

SWMM was used to estimate the long-term capture efficiency and volume reduction from conventional biofiltration BMPs and Filterra systems for each scenario. SWMM compartmentalizes its computations based on several physically-based processes including surface runoff, evaporation, infiltration, and flow routing. A conceptual representation of the SWMM model framework used for this analysis is provided in Figure B.1. Within this framework, parameters were adjusted for each scenario to account for soil condition and BMP sizing and design attributes.

In SWMM, subcatchment elements are used to generate a runoff hydrograph. Input data defining the surface characteristics include subcatchment area, imperviousness, width, depression storage, surface roughness, surface slope, and infiltration parameters. SWMM performs a mass balance

of inflows and outflows to determine runoff from a subcatchment. The inflows to this mass balance are precipitation and any runoff directed from another subcatchment. The outflows from the mass balance include evaporation, infiltration, and runoff. The runoff parameters assumed for this analysis are discussed in this Appendix.

A variety of hydraulic flow routing elements exist in SWMM, but fundamentally, the program includes nodes (i.e., storage units, manholes, and outfalls) and links (i.e., conduits, pipes, pumps, weirs, orifices, and outlets). Storage units were used in this equivalency analysis to represent the storage and routing attributes of BMPs. The elements defining the storage volume and related discharge were adjusted based on the various sizing and design criteria evaluated in the equivalency scenarios, the details of which are discussed in this Appendix.

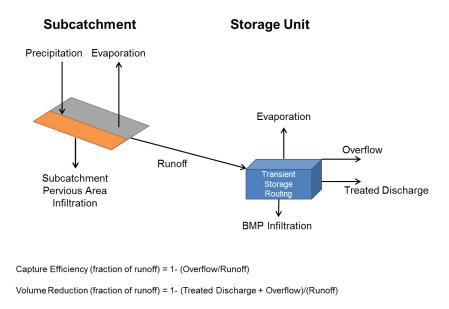


Figure B.1. Schematic SWMM modeling framework in support of equivalency analysis

SWMM was run in continuous simulation mode over a 15-year period (2000-2015). A continuous hydrograph of runoff was generated and routed through the model representations of BMPs. The results were tracked and reported in terms of long term runoff volume, long term volume lost in the BMP, long term volume bypassing or overflowing the BMP, and long term volume treated in the BMP. The 15-year period of record was selected based on the availability of high quality 5-minute resolution precipitation data, which are important for representing urban catchments with short time of concentration. To ensure comparability, the same forcing data (rainfall, ET) were applied to conventional biofiltration scenarios and Filterra scenarios.

Meteorological Inputs

Precipitation

Precipitation data utilized this study included continuous hourly precipitation data collected by the National Climatic Data Center (NCDC) and five-minute precipitation data from the Automated Surface Observation System (ASOS); both part of the National Oceanic and Atmospheric Administration (NOAA). The hourly precipitation datasets from NCDC provided an extensive record of precipitation data from 1948 through February 2015. NCDC precipitation datasets at major airports are known to be of high quality with few areas of missing or unreportable data and therefore were used as a quality standard to compare to the ASOS dataset as well as the basis for estimating long term precipitation statistics. The ASOS dataset does not receive the same level of quality review that the NCDC data and has considerably shorter period of data (ASOS dataset is from 2000 to February 2015). However, the ASOS data is collected at 5-minute intervals, providing considerably better temporal resolution for precipitation when modeling of urban BMPs, particularly for small catchments. Therefore, NCDC data were used to define the 85th percentile 24-hour sizing criteria and to validate the ASOS data, while the ASOS data was used as the input to comparative model simulations. The period of record of ASOS data (15 years) is less than ideal for characterizing long term averages, however because the same dataset was used for both conventional biofiltration and Filterra systems, this length if record is ample to provide a valid comparison of performance.

The Los Angeles Airport location was included in this analysis (NCDC: 045114, ASOS: KLAX). The 85th percentile 24-hour precipitation depth was determined using the entire length of record at the NCDC gage and compared to the values produced from the ASOS gages (Table B-1). In determining the 85th percentile, 24-hour depth, days with 0.1 inches or less were excluded from both datasets. The resulting 85th percentile, 24-hour depths are well matched between the NCDC and ASOS gage. Scatter plot comparisons of NCDC and ASOS datasets for monthly and 24-hour totals at each location also show good agreement (Figure B-1 and Figure B-2). This indicates that the ASOS data provide a reasonable estimate of absolute long term performance in addition to providing a reliable comparison between BMP types.

Table B.1. Summary of 85th percentile 24-hour storm depths.

Storms	Gage Location	85 th Percentile 24-Hour Depth (in)
All NCDC Storms > 0.1 inch (1948-2015)	Los Angeles Airport (045114)	1.01
All ASOS Storms > 0.1 inch (2000-2015)	Los Angeles Airport (KLAX)	0.96

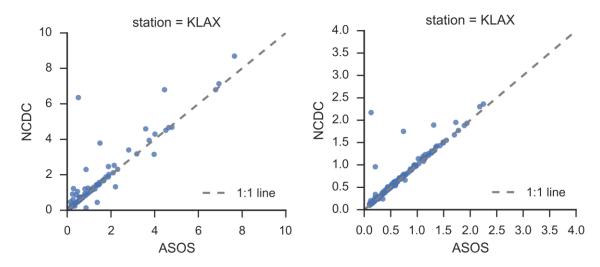


Figure B.2. Scatter plot comparisons of monthly (left) and daily (right) precipitation depths for NCDC and ASOS datasets.

ET Parameters

Reference ET values for Zone 4 of the California Irrigation Management Information System were used to estimate evaporation for all simulations (CDWR 2015). Zone 4 represents coastal areas; actual ET may be higher in inland areas and is likely higher on average in Southern California than the San Francisco Bay Area, however the influence of this assumption is minor and will tend to cancel out in comparison between BMP types. Average ET conditions were represented by setting the modeled evaporation values equal to 60% of the reference ET values to represent a mix of urban conditions with varied plant pallets and shading conditions based on guidance provided by CIMIS (CDWR 2015). The assumed ET values for this analysis are presented in Table B.2.

Table B.2. Assumed ET values for all scenarios

Month	Eva	Evapotranspiration Rates			
Month	inch / day	days / month	inch / month	inch / month	
January	0.05	31	1.55	0.93	
February	0.08	28	2.24	1.34	
March	0.12	31	3.72	2.23	
April	0.17	30	5.1	3.06	
May	0.22	31	6.82	4.09	
June	0.26	30	7.8	4.68	
July	0.28	31	8.68	5.21	
August	0.25	31	7.75	4.65	

Month	Eva	60%		
Month	inch / day	days / month	inch / month	inch / month
September	0.19	30	5.7	3.42
October	0.13	31	4.03	2.42
November	0.07	30	2.1	1.26
December	0.05	31	1.55	0.93
Total (year)		365	57.04	34.22

Runoff Parameters

The key SWMM parameters used to estimate surface runoff are subcatchment area, width, imperviousness, depression storage, surface roughness, surface slope, and infiltration parameters. The majority of surface characteristics were kept constant for both BMP systems and across all land use types. The values assumed for each of these parameters are in Table B.3. Imperviousness was varied for different land uses as described in the Ventura County Technical Guidance Manual for Stormwater Quality Control Measures (Larry Walker Associates and Geosyntec 2011) and is presented for each land use within Table B.3. Additionally, for Filterra simulations, the width parameter (defines the overland flow length for runoff to travel), were adjusted to reflect differences in time of concentrations. The values applied within the model were estimated through an iterative process during the modeling phase.

Runoff estimation is affected by losses to infiltration processes over pervious areas of the subcatchment. The Green-Ampt method of estimating infiltration was used to represent this process. Three input parameters were used to characterize infiltration with this method: initial deficit, saturated hydraulic conductivity, and suction head. These parameters represent surface conditions and are not necessarily related to the saturated infiltration processes that may occur below a BMP (typically several feet below the surface). Because the purpose of this equivalency analysis was to isolate differences between two BMP types, the subcatchment infiltration parameters were held fixed for all scenarios. Parameters were selected to represent typical urban conditions with disturbed urban soils (Table B.3).

Table B.3. Summary of SWMM parameters to represent runoff parameters

SWMM Runoff Parameters	Units	Values	Source/Rationale
Wet time step	seconds	150	Set to half the time steps of precipitation input data (300 seconds)
Dry time step	seconds	14,400	Equivalent to 4 hours.
Period of Record		January 2000-December 2014	Availability of ASOS data

27

SWMM Runoff Parameters	Units	Values	Source/Rationale
Percent of Impervious Area	percent	Multifamily Residential = 74	Los Angeles County Hydrology Manual (2006)
Impervious Manning's n	unitless	0.012	James and James, 2000
Pervious Manning's n	unitless	0.15	James and James, 2000 (mix of dense grass and mulched landscaping)
Drainage area	acres	1	Hypothetical for purpose of analysis
Width	feet	174 feet by default (equates to 250-ft path length) For Filterra scenarios, variable to represent different time of concentrations	Typical assumption for urban drainage patterns
Slopes	ft/ft	0.03 (represents average of roofs, landscaping, and streets)	Professional judgment
Evaporation	in / month	60% of reference ET values (Table B.4)	CIMIS (CWDR, 2015)
Depression storage, impervious	inches	0.02	James and James, 2000
Depression storage, pervious	inches	0.06	James and James, 2000
Saturated Hydraulic Conductivity (in/hr)	in/hr	0.15	EPA SWMM User's Manual for typical disturbed urban soils
Initial Moisture Deficit (in/in)	in/in	0.29	EPA SWMM User's Manual for typical disturbed urban soils
Maximum Suction Head (inches)	inches	8	EPA SWMM User's Manual for typical disturbed urban soils

BMP Representation

Both the conventional biofiltration BMPs and Filterra systems were simulated using a storage unit with outlets to represent infiltration losses (if present) and treated discharge, and a weir to represent overflow/bypass. The elevations of these elements within the storage unit were used to represent the design profiles of these systems. Storage compartments were broken into: evaporation storage (i.e., water stored in soil that is not freely drained); infiltration storage (i.e., water stored below the lowest outlet that can either infiltration or ET only); and freely drained storage (i.e., water that can drain through the underdrains of the system at a rate controlled by the

media hydraulic conductivity). In some scenarios an additional storage unit was located downstream of the Filterra BMP to represent additional retention storage.

Conventional Biofiltration

Sizing criteria for the conventional biofiltration system was based on the runoff from the 85th percentile, 24-hour storm depth (1.0 for LAX). For each scenario, this depth was applied to the catchment area and imperviousness to compute an estimated runoff volume. Storage profiles for the conventional biofiltration system were established to represent typical profiles for conventional biofiltration consistent with what is required by Attachment H of the MS4 Permit, which are presented in Appendix A. The storage profiles included equivalent storage volumes provided in the ponding depth, media depth (divided between ET storage and freely drained storage), gravel layer, and placement of the underdrain system specific to the site conditions. Based on the equivalent storage depth in these profiles and the design storm runoff volume, the required footprints were calculated. For gravel, a porosity of 0.4 was assumed. For media, a porosity of 0.4 in/in was assumed, divided as 0.15 in/in soil suction storage (i.e. ET storage) and 0.25 in/in freely drained storage. The profiles used for this analysis and the typical footprints are presented in Table B.4.

For the purpose of estimating long term volume reduction and baseline capture efficiency, the entire pore volume was assumed to be immediately available. However, because water takes time to travel through the soil column, it is possible for a biofiltration BMP to overflow before the entire soil poor volume is utilized. Based on analysis of flow monitoring data, Davis et al. (2011) found that the volume immediately available within a storm is better represented by the bowl volume (surface ponding) and the freely drained pores within the root zone (approximately the top 1 foot of soil). To check whether this condition controlled, parallel model runs were conducted where the storage volume equaled the bowl volume plus freely drained pores in the soil root zone, and the drawdown time was adjusted for only this volume. The result was that this condition reduced capture efficiency by approximately 2 percent. This indicates that this condition controls performance relatively rarely, but is not negligible.

Table B.4. Summary	of co	onventional	bio	filtratio	n	profiles
--------------------	-------	-------------	-----	-----------	---	----------

						1	
				Effective			
	Retention	Effective		Water		Total	Approximate
	Sump	Water		Storage		Effective	Footprint
	Depth (as	Storage in	Media	in	Ponding	Water	Sizing
Infiltration	gravel	Retention	Depth,	Media ² ,	Depth,	Depth	Factor (Los
Rate, in/hr	depth) ¹ , ft	Sump (ft)	ft	ft	ft	(ft)	Angeles) ³
0.3	1.5	0.60	2	0.8	1.5	2.9	1.5%
0.15	0.75	0.30	2	0.8	1.5	2.6	1.6%
0.05	0.25	0.10	2	0.8	1.5	2.4	1.7%
0.01	0.05	0.02	2	0.8	1.5	2.32	1.7%
0	0	0.00	2	0.8	1.5	2.3	1.8%

¹ Sump storage was determined based on the depth of water that would infiltrate in 24 hours based on guidance provided in Attachment H.

Filterra

An array of flow-based sizing increments were applied to define the physical dimensions of the Filterra system to be modeled in each scenario. Ten increments of uniform design intensities ranging from 0.1 inches/hour up to 0.8 inches/hour (0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.5, 0.6, 0.8) were established to represent a range of potential Filterra sizing criteria to achieve equivalency. For each scenario, the design intensity was applied to the catchment area and imperviousness to calculate the runoff flowrate. The treatment capacity of the Filterra system was set at 140 in/hr (or 0.0032 cu-ft/sec per sq-ft). Based on the required treatment flowrate and the Filterra treatment capacity, the required Filterra footprint was determined.³ Similar to the conventional biofiltration system, a vertical profile was also established as an input to the model, including ponding depth, pore space in mulch and media, and underdrains (Table B.5). The volume of the Filterra system is negligible; however the entire volume was assumed to be available as a result of the very high infiltration rate of the Filterra media.

Further scenarios were developed for the Filterra system that included supplemental downstream retention. These supplemental storage volumes were sized based on a percentage of the runoff volume from the 85th percentile, 24-hour depth (0% (absent), 10%, 20%, 30%, 40%, 50%). For these scenarios, an additional storage unit was simulated and received the treated flow from the

² Media storage depth divided as 0.3 ft suction storage and 0.5 ft freely drained storage.

³ Expressed as BMP footprint as percent of tributary area; Multi-family density of 74% impervious was used as a representative value for simulations.

³ In practice, designers would select a standard Filterra size that meets or exceeds the required design flowrate, therefore many systems will tend to be oversized in practice; the approach used for this equivalency analysis is conservative in that it assumes exactly the minimum size is used.

upstream Filterra storage unit. The profile of the Filterra system is described in Table B.5. The downstream retention unit was modeled with an assumed depth of 2.1 feet, based on typical Contech ChamberMaxx system geometry, assuming 6 inches gravel above and below the ChamberMaxx units.

Table B.5. Summary of profile for Filterra systems

				Effective			
		Effective		Water		Total	Approximate
Media		Water		Storage		Effective	Footprint
Filtration	Gravel	Storage in	Media	in	Ponding	Water	Sizing for
Rate,	Underdrain ¹ ,	Retention	Depth,	Media ² ,	Depth,	Depth	0.3 in/hr
in/hr	ft	Sump (ft)	ft	ft	ft	(ft)	scenario ³
140	0.5	0.2	2	0.5	0.5	2.4	0.19%

¹ Gravel layer based on typical Filterra design; all of the gravel layer was assumed to drain freely to the underdrain

² Media storage depth divided as 0.3 ft suction storage and 0.5 ft freely drained storage.

³ Expressed as BMP footprint as percent of tributary impervious area (varies by land use and sizing increment; for example purposes only).

APPENDIX C – DATASETS AND ANALYSIS METHODS FOR POLLUTANT TREATMENT EVALUATION

Data Development and Analysis Framework

BMP performance is considered to be a function of BMP type, BMP design parameters, influent water quality characteristics, and other factors. As part of this analysis, it was necessary to develop a statistical description of BMP performance that accounted for the difference between conventional biofiltration and Filterra systems and also accounted for the influence of land use runoff quality (i.e., BMP influent quality) on the expected BMP performance. The data development and analysis framework used for this project included four steps:

- 1) Compile and review data from monitoring studies of conventional bioretention systems; then screen these studies to identify studies that are reasonably representative of conventional biofiltration designs that would meet the MS4 Permit requirements, particularly focusing on factors that would influence treated effluent quality.
- 2) Compile and review monitoring data from full-scale monitoring studies of Filterra systems.
- 3) Apply a common statistical analysis framework to analyze the data from both datasets.
- 4) Determine representative land use runoff quality.
- 5) Based on results from step 3 and 4, estimate the effluent quality expected for conventional biofiltration and Filterra systems for each pollutant for a range of land use types.

Compilation and Screening of Conventional Biofiltration Studies

The International Stormwater BMP Database (www.bmpdatabase.org) includes storm event monitoring data from 28 peer-reviewed studies of bioretention BMPs with underdrains. These data were used as the primary source for characterizing the treatment performance of conventional biofiltration BMPs in this study. In addition to the 28 studies from the International BMP Database, four peer-reviewed research studies (Davis 2007; Li and Davis 2009; David et al., 2011; Gilbreath et al. 2012) not contained in the International BMP Database were added to the sample pool for analysis. Two of these studies were conducted recently in the San Francisco Bay area, which has biofiltration design standards and media specifications nearly identical to Attachment H of the Los Angeles MS4 Permit. The two other additional studies were included due to their similarity to Attachment H design criteria and rigor of their analytical methods.

Screening Process for Developing Conventional Biofiltration Sample Pool

To our knowledge, there have yet to be any BMPs monitored in Southern California that have been constructed to the specific criteria of Attachment H. Additionally, the two studies monitored in the San Francisco Bay area (designed to very similar standards as Attachment H)

(David et al., 2011; Gilbreath et al. 2012) provide a relatively small sample size and did not monitor for nutrients. Therefore, it was necessary to broaden the scope of studies to represent conventional biofiltration.

In general, the bioretention BMPs in the International BMP Database are considered to be representative of the range of designs that could meet the MS4 Permit Attachment H requirements. Most of the bioretention studies in the BMP Database were completed fairly recently (most in the last 10 years) and have typically been designed, constructed, and/or monitored under the supervision of experienced researchers. Many of these systems have been designed with BMP profiles (i.e., ponding depth, media depth), media filtration rates, and media composition that are similar to the criteria in Attachment H. However, where design attributes indicated that performance would be expected to be poorer than Attachment H designs and/or representativeness could not be evaluated, these studies were screened out of the analysis pool for this study. Systems that were expected to achieve similar or better performance than a typical BMP designed per Attachment H were kept in the pool; this is a conservative approach when evaluating Filterra equivalency because it tends to establish a higher baseline for comparison than if these BMPs were excluded.

Screening criteria were developed based on professional judgment, as informed by review of literature and BMP performance studies. Our understanding of the influence of design parameters on bioretention performance was informed by studies in the BMP Database (see various summary reports at www.bmpdatabase.org), a recent evaluation by Roseen and Stone (2013), and review of recent bioretention media research in Washington State. A summary of the relevant findings are provided in the paragraphs below.

Roseen and Stone (2013) conducted an evaluation of biofiltration performance to determine how design criteria and media composition influence performance. As part of their research, they compiled site, design, and performance data for 80 field bioretention systems and 114 lab columns/mesocosms. Data from the International BMP Database were included in this pool as well as other research studies. Performance data were compiled as study summaries (e.g., study median influent, effluent, and removal efficiency). Roseen and Stone then utilized design information to categorizing systems into groups based on common combinations of factors. They then conducted a statistical evaluation of how performance was influenced by design factors such as presence/absence of mulch layers, use of compost in media, infiltration rate of media, ratio of tributary to biofiltration area, presence/absence of pretreatment, presence/absence of internal storage layers, etc. Roseen and Stone found that the presence of compost in mixes strongly influences the variability in performance and potential export of pollutants, including phosphorus, nitrogen, and copper. Systems without compost and/or with a high fraction of sand tended to provide the most consistent and best performance for these pollutants. Systems with an

internal water storage zone tended to perform better for nutrients than systems without an internal water storage zone. Finally, they found that media flowrate and depth of media bed tended to have an influence on performance. Beyond these findings, the influence of other parameters was less conclusive.

Recent bioretention studies, many in Washington State (Herrera 2014b, 2015a, 2015b), have identified the potential severity of pollutant export of nitrogen, phosphorus, and copper from conventional biofiltration systems and have evaluated the potential sources of these issues. For example, a full scale field monitoring study in the City of Redmond (WA) observed export of nitrate on the scale of 100 mg/L higher than influent quality and dissolved copper on the scale of 10 to 20 ug/L higher than influent. Follow up research has shown that compost is consistently associated with export of copper, nitrogen and phosphorus, even when the highest quality compost products available are used in designs and at proportions as low as 10% of the media blend by volume. This research also found that some sand products can also contain elevated levels of phosphorus and copper. These studies are relevant because the standard biofiltration media specifications for Western Washington are very similar to Attachment H, calling for 60 to 65 percent sand and 35 to 40 percent compost. It should also be noted that the compost certification criteria in Washington State (Washington Department of Ecology, 2014) allow for half as much metals content as allowed in the Attachment H specification, therefore should theoretically have less potential for export of metals than compost meeting the Attachment H specification.

Based on these literature findings and best professional judgment, the following criteria were applied as part of screening bioretention studies:

- Systems with media filtration rates substantially higher than 12 inches per hour were excluded while higher rate media has been found to provide good performance in some cases, the general trends observed by Roseen and Stone (2013) indicated a decline in performance for some parameters with increased infiltration rates.
- Systems with sizing factors (BMP area as fraction of tributary area) substantially smaller than the 3 to 5 percent (20:1 to 30:1 ratio of tributary area to BMP area) were excluded this parameter is related to media filtration rate and is an indicator of the degree of hydraulic loading.
- Systems that were observed to have very infrequent underdrain discharge (i.e., mostly infiltration) were excluded for these designs, the effluent that was sampled for water quality was likely not representative of the entire storm event.
- Systems with internal water storage zones were kept in the pool of data; these systems are believed to provide better control of nutrients than systems without internal water storage; Attachment H does not require internal water storage to be provided.

- Based on the findings of Roseen and Stone (2013) as well as recent research in Washington State, mixes with less compost and a higher fraction of sand than the Attachment H specification were kept in the sample pool because they are believed to provide more reliable performance and less potential for export of pollutants on average than a 70-30 sand/compost mix.
- Systems that contained media with experimental components were excluded.
- Finally, systems were excluded if there was not enough design information reported to be
 able to evaluate representativeness, and/or any other factors were noted by the original
 study researchers that were believed to contribute to poorer performance than average.
 For example, some studies were noted as underperforming studies due to construction
 issues, premature clogging, etc.

Overall, the screening that was applied is believed to improve the representativeness of the sample pool and generally increase the average performance of the sample pool compared to the entire pool of studies contained in the International BMP Database. As discussed above, establishing a higher baseline level of performance for conventional biofiltration is conservative in the context of this evaluation.

Screening Results

Table C.2 summarizes the number of data points for each constituent after applying screening to remove unrepresentative studies and without screening.

Table C.2. Summary of data points by parameter for conventional biofiltration BMPs

Constituent	Number of Screened Data Pairs	Number of Unscreened Data Pairs
Total Suspended Solids	234	354
Total Phosphorus	242	384
Total Nitrogen	71	184
Total Copper	190	216
Total Zinc	200	252

Inventory of Bioretention Studies and Screening Results/Rationales

Table C.4 (located at the end of this Appendix) provides an inventory of studies of bioretention with underdrains from the International BMP Database, screening results, and brief rationales for screening.

Compilation of Filterra Studies

Data were compiled from various field-scale Filterra monitoring studies from 2004 through 2014. The design of the Filterra system has not changed appreciably over time; therefore a screening step to determine representative studies was not necessary. The studies used in this analysis are summarized in Table 3 below. Full citations for these studies can be found in the references section.

Table C.3. Inventory of studies and data points by parameter for Filterra systems

Pollutant (total count of data pairs)	Data Pairs by Study	Reference			
	11	TARP (2004-2005): Yu and Stanford (2006)			
	7	TARP Addendum (2006-2007): ATR Associates (2009)			
	25	Perf. Over Time: Cal's Pizza (2008-2014): Americast (2009b; 2015)			
Total Suspended Solids	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)			
(n= 165)	13	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)			
	29	NCDNR Fayetteville (2013-14): NCSU (2015a)			
	22	TAPE Bellingham (2013): Herrera (2014a)			
	34	TAPE Port of Tacoma (2009): Herrera (2009)			
	14	TARP (2004-2005): Yu and Stanford (2006)			
Total Phosphorus	6	TARP Addendum (2006-2007): ATR Associates (2009)			
(n=146)	71	Perf. Over Time: Cal's Pizza (2008-2014): Americast (2009b; 2015)			
	33	NCDNR Fayetteville (2013-14): NCSU (2015a)			
	22	TAPE Bellingham (2013): Herrera (2014a)			
Total Nitrogen (n = 34)	34	NCDNR Fayetteville (2013-14): NCSU (2015a)			
	8	TARP (2004-2005): Yu and Stanford (2006)			
	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)			
Total Copper	21	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)			
(n = 112)	13	NCDNR Fayetteville (2013-14): NCSU (2015a)			
	29	TAPE Port of Tacoma (2009): Herrera (2009)			
	17	TAPE Bellingham (2013): Herrera (2014a)			

Pollutant (total count of data pairs)	Data Pairs by Study	Reference
	16	TARP (2004-2005): Yu and Stanford (2006)
	24	Perf. Over Time: Jiffy Lube (2008-2011): Americast (2009b; 2015)
Total Zinc	21	Perf. Over Time: Coliseum (2007-2014): Americast (2009b, 2015)
(n = 120)	13	NCDNR Fayetteville (2013-14): NCSU (2015a)
	29	TAPE Port of Tacoma (2009): Herrera (2009)
	17	TAPE Bellingham (2013): Herrera (2014a)

Key to acronyms:

TARP: Technology Acceptance Reciprocity Partnership

TAPE: Technology Acceptance Protocol-Ecology (Washington State)

NCDNR: North Carolina Department of Natural Resources

NCSU: North Carolina State University

Data Analysis Method

The most common ways to characterize BMP performance include (1) removal efficiency (percent removal) in various forms, and (2) effluent probability. In general, the effluent probability approach is recommended for evaluating BMP performance and applying BMP performance to pollutant load models (Geosyntec and Wright Water, 2009). This method involves conducting a statistical comparison of influent and effluent quality to determine if effluent is significantly different from influent. If effluent is significantly different from influent, then the effluent quality is characterized by a statistical distribution developed from all effluent data points. Probability plots are prepared indicating the probability that a certain effluent quality is achieved.

However, to isolate differences in performance between two BMP types, the effluent probability method requires the assumption that the influent quality was similar between the studies of the two BMP types being compared. This assumption is generally reliable for categorical analysis of BMPs in the International BMP Database because of the large number of studies in the most categories in the Database. However, when comparing BMP types with a relatively limited number of study sites (such as the Filterra dataset), this assumption may not be reliable.

To address these challenges and help ensure a valid comparison between conventional biofiltration and Filterra systems, a moving bootstrap method (Leisenring et al., 2009) was applied to both datasets. This method characterizes influent-effluent relationships such that the BMPs compared do not need to have been studied under conditions with similar influent quality. In this approach, all data pairs are used to form the total sample population. Then for each increment of influent quality, a subsample of the overall population is formed including only those data pairs that lie within a certain span of the selected influent quality. Applying bootstrap

principles (Singh and Xie, 2008), the median and the confidence interval around the median is computed as well the mean and the confidence interval around the mean. Then a new increment of influent quality is selected and the process is repeated with a new subsample population until a statistical description of effluent quality has been developed for each increment of influent quality over the range of the data. Rules are also imposed regarding selection the initial span of the moving window and expansion the span of the window, if needed, to ensure monotonicity (i.e., ensure that effluent quality always increases or stays the same with increasing influent quality).

Resulting tables and plots from this analysis are presented in Appendix D.

Land Use Stormwater Quality Inputs and Assumptions

Representative stormwater runoff concentrations for the land use condition used in this analysis were developed based on the land use stormwater quality monitoring data reported in the Los Angeles County 1994-2000 Integrated Receiving Water Impacts Report, 2000 and Los Angeles County 2000-2001 Stormwater Monitoring Report, 2001(LA County 2000; LA County 2001). The median and mean runoff quality values from this dataset were used as representative influent water quality conditions for the purpose of evaluating BMP performance. These concentrations represent only one land use monitoring station in one geographic area; actual conditions for a given drainage area in a given region are anticipated to vary. Beyond the range of water quality presented in this table, this analysis did not attempt to characterize the uncertainty/variability in runoff water quality. This simplification is considered appropriate for evaluating equivalency in BMP performance.

Land use runoff quality is reported in Appendix D.

Table C.4. Inventory of conventional biofiltration studies from the International BMP Database and screening rationale

	Tauonaie											
Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons						
Int. BMP Database	Rocky Mount Grassed Bioretention Cell 1	North Carolina State	NC	Rocky Mount	Yes	Aligns with Att. H; Has internal water storage zone and underdrain						
Int. BMP Database	Rocky Mount Mulch/Shrub Bioretention Cell 1	North Carolina State	NC	Rocky Mount	Yes	Aligns with Att. H; Has internal water storage zone and underdrain						
Int. BMP Database	CHS_BioFilter	The Thomas Jefferson Planning District Commission	VA	Charlottesville	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer (0.25 feet)						
Int. BMP Database	Parks & Forestry Bioretention	City of Overland Park	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer						
Int. BMP Database	Bioretention 6	Johnson County	KS	Shawnee	Yes	Aligns with Att. H; Has internal water storage zone and underdrain						
Int. BMP Database	G2	North Carolina State	NC	Greensboro	Yes	Aligns with Att. H; Has underdrain, and mulch layer (7-10 cm)						
Int. BMP Database	G1	North Carolina State	NC	Greensboro	Yes	Aligns with Att. H; Has underdrain, and mulch layer (7-10 cm)						
Int. BMP Database	L1	North Carolina State	NC	Louisburg	Yes	Aligns with Att. H; Appropriate loading ratio						
Int. BMP Database	Bioretention 3B	Johnson County	KS	Shawnee	Yes	Aligns with Att. H; Has internal water storage zone and underdrain						
Int. BMP Database	Parking Lot Bioretention Cell	City of Fort Collins	СО	Fort Collins	Yes	Aligns with Att. H; Has internal water storage zone and mulch layer						

Filterra Equivalency Analysis August 2015

Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons
Int. BMP Database	Bioretention Cells	Johnson County SMP	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and mulch layer
Int. BMP Database	Bioretention Cell	Johnson County SMP	KS	Overland Park	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Int. BMP Database	Bioretention System (D1)	UNH/Cooperative Institute for Coastal and Estuarine Environmental Technology	NH	Durham	Yes	Aligns with Att. H; Has pretreatment, internal water storage zone, underdrain, and mulch layer
Int. BMP Database	UDFCD Rain Garden	Urban Drainage and Flood Control District	СО	Lakewood	Yes	Aligns with Att. H; Has internal water storage zone, underdrain, and compost layer
Int. BMP Database	Hal Marshall Bioretention Cell	City of Charlotte, North Carolina	NC	Charlotte	Yes	Aligns with Att. H; Has underdrain, and mulch layer
Int. BMP Database	Rocky Mount Grassed Bioretention Cell 2	The Cooperative Institute for Coastal and Estuarine Environmental Technology	NC	Rocky Mountain	Yes	Aligns with Att. H; Has internal water storage zone and underdrain
Li and Davis (2009)	Bioretention Cell 1	Prince George's County Department of Environmental Resources/ U of MD	MD	College Park	Yes	Aligns with Att. H
Li and Davis (2009)	Bioretention Cell 2	Prince George's County Department of Environmental Resources/U of MD	MD	Silver Spring	Yes	Aligns with Att. H
Davis (2007)	Bioretention Cell 1	Prince George's County Department of Environmental Resources/U of MD	MD	College Park	Yes	Aligns with Att. H
David et al. (2011)	Daly City Library Rain Gardens	San Francisco Estuary Institute	CA	Daly City	Yes	Aligns with Att. H
Gilbreath et al. (2012)	San Pablo Ave Green Streets	San Francisco Estuary Institute	CA	El Cerrito	Yes	Aligns with Att. H
Int. BMP Database	Bioretention Area	Virginia Department of Conservation and Recreation	VA	Charlottesville	No	Not enough design info provided
Int. BMP Database	Small Cell	North Carolina Department of Transportation	NC	Knightdale	No	Infiltration rate low; noted to be underperforming BMP by

Filterra Equivalency Analysis August 2015

Source	Site Name	Sponsoring Entity	State	City	Selected?	Selection/Rejection Reasons
Source	Site 1 table				Serected	study researchers
Int. BMP Database	BRC_B	North Carolina State	NC	Nashville	No	Infiltration too low and undersized
Int. BMP Database	North cell	North Carolina State	NC	Raleigh	No	Media very different from Att. H
Int. BMP Database	WA Ecology Embankment at SR 167 MP 16.4	Washington State Dept. of Transportation	WA	Olympia	No	Linear design; lateral flow; not representative of typical biofiltration design
Int. BMP Database	Bioretention Cell	Delaware Department of Transportation	DE	Dover	No	Design is very different from Att. H
Int. BMP Database	East 44th St. Pond	City of Tacoma	WA	Tacoma	No	No design data
Int. BMP Database	Tree Filter	UNH/Cooperative Institute for Coastal and Estuarine Environmental Technology	NH	Durham	No	Design is very different from Att. H
Int. BMP Database	BRC_A	North Carolina State University	NC	Raleigh	No	Infiltration rate very low; noted to be a partially clogged/failing system
Int. BMP Database	Cub_Run_Biorete ntion	Fairfax County	VA	Fairfax	No	No design data provided
Int. BMP Database	South cell	North Carolina State University (BAE)	NC	Raleigh	No	Design is very different from Att. H
Int. BMP Database	R Street	City of Tacoma	WA	Tacoma	No	No design data provided

APPENDIX D – RESULTS OF POLLUTANT TREATMENT DATA ANALYSIS

The data analysis methods described in Appendix C were applied to the datasets described in Appendix C. The following pages present tabular and graphical results of this analysis.

Table D.1. Summary Statistics - Bioretention Studies and Filterra Studies

Median Statistics

			Median Representative	Conventional Biofiltration Effluent (Screened)		Conventional Biofiltration Effluent (Unscreened)		Filterra Effluent	
Land Use	Pollutant	Units	Runoff Quality	Median	95th percentile UCL on Median	Median	95th percentile UCL on Median	Median	95th percentile UCL on Median
	TSS	mg/L	53	12	13.7	11	12	4.9	5
	Total Phosphorus	mg/L	0.27	0.46	0.55	0.26	0.37	0.06	0.08
Commercial	Total Nitrogen	mg/L	2.3	1.6	2.9	1.19	1.52	1	1.6
	Copper	ug/L	22	12	15	12	14	10	10
	Zinc	ug/L	192	35	44	36	40	70	77
	TSS	mg/L	61	12	15	12	13	5.0	5.0
High Density Single	Total Phosphorus	mg/L	0.32	0.47	0.55	0.28	0.43	0.09	0.11
Family Residential	Total Nitrogen	mg/L	2	1.6	2.9	1.2	1.5	1	1.6
railing Residential	Copper	ug/L	11	5.3	5.9	5.3	6.4	5.5	6.0
	Zinc	ug/L	66	20	27	18	26	31	35
	TSS	mg/L	129	16	18	16	18	5.2	7.0
	Total Phosphorus	mg/L	0.3	0.47	0.55	0.27	0.42	0.09	0.11
Light Industrial	Total Nitrogen	mg/L	2.4	1.6	2.9	1.2	1.5	1.3	1.6
	Copper	ug/L	21	12	15	12	13.85	10	10
	Zinc	ug/L	366	35	44	36	40	80	95
	TSS	mg/L	24	10.8	12.5	9.9	9.9	3	3
Multi-family	Total Phosphorus	mg/L	0.14	0.39	0.45	0.21	0.25	0.04	0.05
Residential	Total Nitrogen	mg/L	1.5	1.6	2.9	1.2	1.5	0.9	1
nesidelitidi	Copper	ug/L	12	5.6	6.1	5.6	6.6	5.5	6.0
	Zinc	ug/L	89	20	27	18	26	35	37

Mean Statistics

Land Use	Pollutant	Units	Mean Representative Runoff Quality	Conventional Biofiltration Effluent (Screened)		Conventional Biofiltrati	on Effluent (Unscreened)	Filterra Effluent	
Land Ose	Pollutant	Onits	Runoff Quality	Mean	95th percentile UCL on Mean	Mean	95th percentile UCL on Mean	Mean	95th percentile UCL on Mean
	TSS	mg/L	66	28	49	25	39	6.0	7.9
	Total Phosphorus	mg/L	0.39	0.80	1.3	0.65	1.0	0.11	0.14
Commercial	Total Nitrogen	mg/L	3.6	2.9	4.3	2.1	2.8	NA	NA
	Copper	ug/L	39	19	29	16	24	18	29
	Zinc	ug/L	241	65	145	59	108	69	105
	TSS	mg/L	95	28	49	25	39	6.0	8.5
High Density Single	Total Phosphorus	mg/L	0.39	0.80	1.3	0.65	1.0	0.11	0.14
Family Residential	Total Nitrogen	mg/L	3.0	2.9	4.3	2.1	2.8	NA	NA
ranning residential	Copper	ug/L	15	13	21	13	19	12	19
	Zinc	ug/L	79	33	50	32	46	28	45
	TSS	mg/L	240	46	105	40	87	16	31
	Total Phosphorus	mg/L	0.41	0.80	1.3	0.65	1.0	0.11	0.14
Light Industrial	Total Nitrogen	mg/L	3.1	2.9	4.3	2.1	2.8	NA	NA
	Copper	ug/L	32	19	29	16	24	18	29
	Zinc	ug/L	639	NA	NA	59	108	168	285
	TSS	mg/L	46	18	28	18	27	6.0	7.9
Multi-family	Total Phosphorus	mg/L	0.2	0.8	1.3	0.6	1.0	0.06	0.07
Residential	Total Nitrogen	mg/L	2.1	2.9	4.3	2.1	2.8	1.1	1.5
Residential	Copper	ug/L	12	10	15	9	14	9	15
	Zinc	ug/L	146	45	90	32	46	38	60

NA - Average values could not be computed for because the land use average influent is outside of the range of influent observed in monitoring studies.

Key to cell formatting

Red bold indicates median or mean effluent concentration higher than influent concentration. This is indicative of the potential for pollutant export.

Blue indicates upper confidence interval of effluent concentration is higher than the influent concentration. This is not a conclusive indicator, but is provided for reference.

Figure D.1 Moving Window Plots of Medians

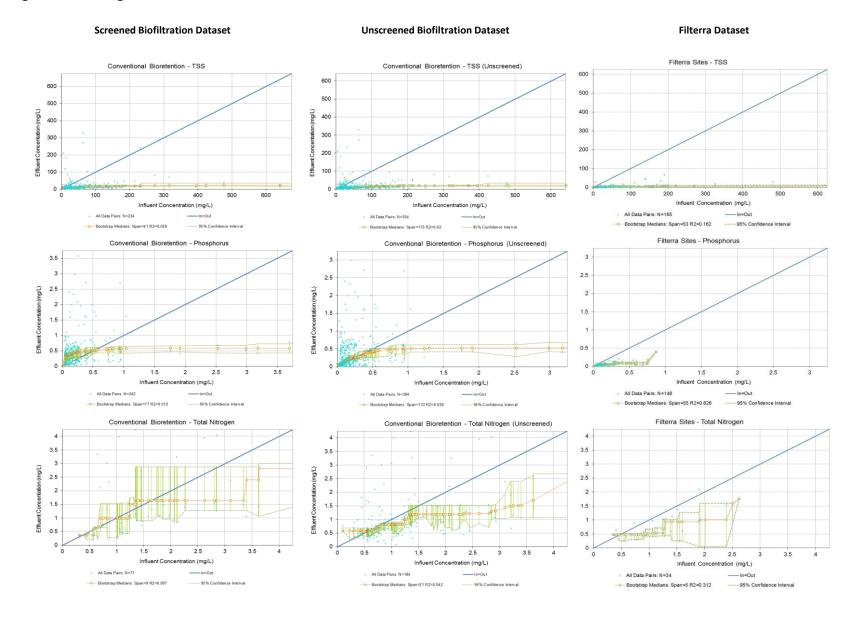


Figure D.1 Moving Window Plots of Medians

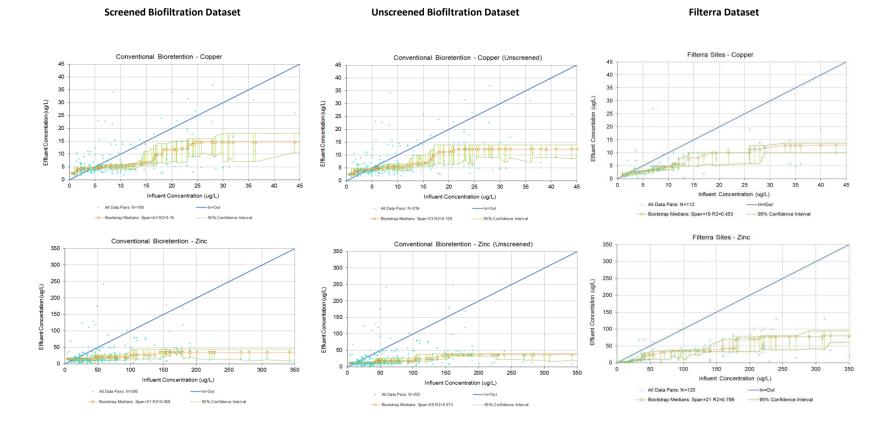


Figure D.2 Moving Window Plots of Means

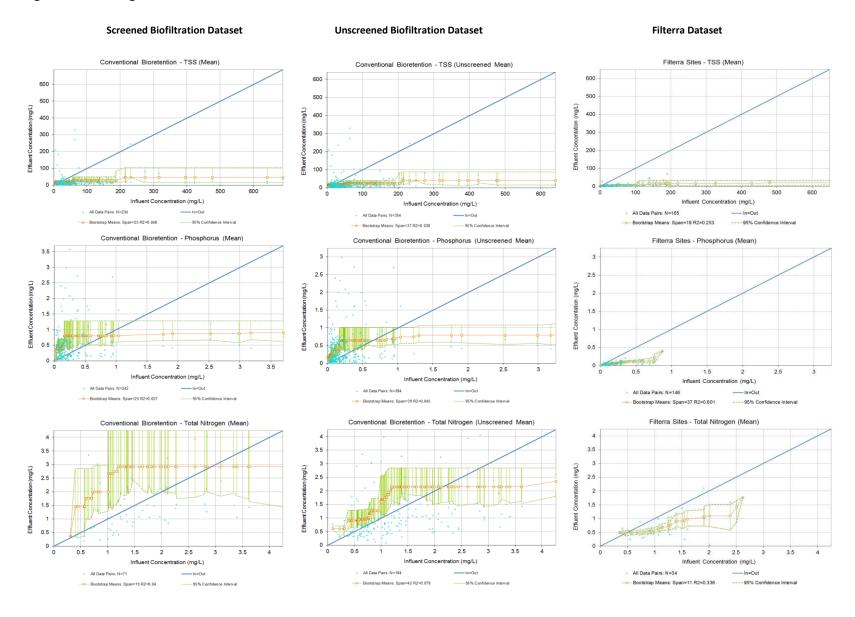


Figure D.2 Moving Window Plots of Means

